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ABSTRACT

This book is designed to develop sequentially a range of concepts and skills relevant to the basic disciplines of science. Emphasis has been given to the knowledge basis of science, the social context of science, design and technology, and knowledge and skills relevant to personal development. Students are provided an opportunity to engage in guided and unguided inquiry, use library references, and to ask other people for information. Students are encouraged to record their observations, make tables, make drawings, and note their conclusions. Chapters include: (1) "You Are a Scientist"; (2) "The Nature of Living Things"; (3) "Using our Senses"; (4) "The World through the Microscope"; (5) "Water"; (6) "Plants and Soils"; (7) "Magnetism"; and (8) "Heating and Separating Chemical Substances." Each chapter includes background information, activities, experiments, and revision questions. Activities and experiments list materials, procedures, and questions. Appendices include a skills and sequence chart, laboratory safety rules, writing a report, and a glossary. (CW)

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SCIENCE FOR THE FUTURE

Book One

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NELSON

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ABOUT THIS BOOK

This is the first in a series of four books which develop sequentially a range of concepts and skills relevant to the basic disciplines of science. Wherever possible an interdisciplinary approach has been taken.

Why **Science for the Future**? Emphasis has been given to the knowledge basis of science but also to:

- the social context of science
- design and technology
- knowledge and skills relevant to personal development.

The book provides the opportunity for students to engage in guided and unguided inquiry, and provides work they can do on their own. Students are encouraged to use the library and make regular references to dictionaries and encylopedias, to ask other people for information and to discuss ideas, questions and findings with each other.

Students are also encouraged to record their observations, draw up tables, do drawings and make notes of their conclusions. The emphasis is on communication.

The book can by used in a variety of ways to meet different teaching/learning situations. It is assumed that teachers will make their own decisions about how to use the book. Here are some considerations:

- Chapter 1 focuses on various skills required for experimentation. You may prefer to break it up and work on it alongside other chapters.
- You may wish to change the order of the chapters to meet your personal preferences.
- Since there is more than enough material available for a year's work, you will need to select activities for students.
- At any point, feel free to take up a topic, idea or activity and develop it according to student needs or interest.

Each chapter includes:

- a list of questions outlining the objectives of the chapter
- activities and experiments for students to complete. Some of these can be done at home. (You can perform others as demonstrations.)
- a summary
- a set of revision questions

New words are set in bold type, and there is a glossary to which students can refer at the end of the book. Students are encouraged to keep their own lists of new words.

Skills/objectives chart

Chapter	Content	Main skills	Using resources	Measuring	Discussing/ communicating	Classifying	Experimenting	Recording results
1 You are a scientist	Getting started	Designed to make students curious and ask questions	●	●	●		●	●
	Scientists	Identifying things scientists do Selecting a problem to investigate						
	Using resources	Identifying sources of information Using resources to answer questions						
	Finding out about experiments	Observing Recording Making hypotheses Testing hypotheses						
	Measuring, graphing and averaging	Measuring Making a scale Graphing Averaging Using a thermometer Controlling variables						
	The uses and influences of science	Comparing the influences of some scientific applications on our lives						
2 The nature of living things	Getting to know the living Movement Feeding Respiration Excretion Responding to stimuli Reproduction Growth	Comparing animals and plants Observing Recording results Making conclusions			●	●	●	●
3 Using your senses	You and your senses Long-distance senses (sight and hearing) Short-distance senses (touch, taste, smell) Senses that are faulty	Using resources Relating common sensory experiences Investigating how we use our senses Discussing the importance of the senses	●	●	●		●	●

Chapter	Content	Main skills	Using resources	Measuring	Discussing/ communicating	Classifying	Experimenting	Recording results
4 The world through the microscope	Exploring with a microscope Cells — the building blocks of life	Setting up a microscope Using a microscope Calculating magnification Observing small things Drawing what is observed Preparing a slide Making a model cell	▨		▨	▨	▨	▨
5 Water	Investigating water and heat Solutions Making crystals	Using simple apparatus Making careful observations Writing simple reports of observations Making predictions	▨	▨	▨		▨	▨
6 Plants and soils	Plant requirements Soil More soil differences	Dissecting flowers and seeds Investigating plants and soil Using a key Describing experiments Measuring mass Striking plant cuttings	▨	▨	▨	▨	▨	▨
7 Magnetism	Introducing magnetism Strengths of magnetic forces Making magnets Uses of magnetism	Measuring Averaging Tabulating results Classifying Evaluating the importance of magnets	▨	▨	▨	▨	▨	▨
8 Heating and separating chemical substances	What is the effect of heat on substances Separating mixtures	Using simple apparatus safely Recording observations accurately Designing experiments Investigating common substances Using simple separation techniques	▨		▨	▨	▨	▨

Laboratory safety rules

1 Keep the working areas tidy.

2 Keep floors and doorways uncluttered.

3 Never play with fire.

4 Don't run or behave boisterously in the laboratory. Make all your movements calm and gentle.

5 Never pick up broken glass with your bare hands.

6 Never put solids into the sinks. Put solid waste into a special bin.

7 Report accidents and any damaged equipment to your teacher.

8 Make sure your working area is well ventilated.

9 Make sure that there are no naked flames near flammable liquids.

10 Make sure that you know the correct ways of handling equipment.

11 Wash your hands after using chemicals or biological materials.

12 Make sure that you know where the fire extinguisher and the first aid kit are.

1 YOU ARE A SCIENTIST

Science is the key to an exciting way of looking at the world. It is a way of finding out about you and what is around you. Science also involves using what you know to change the way in which you live.

This chapter will help you to answer the following questions:

- What are the ways in which scientists go about their work?
- How do you do an experiment?
- How can you be sure about what your experiment tells you?
- How are measurements recorded in graphs?
- How do you work out an average?
- What are some things that scientists have discovered?
- What are some ways in which scientists change the way you live?

GETTING STARTED

Scientists sometimes find out things about the world by doing **experiments**. An experiment is an investigation to find out why something happens.

Let us try a few experiments of our own. Your teacher will demonstrate some of these and others you can do yourself. The experiments are on different topics. You can start being a scientist by seeing how well you can observe.

Some of the experiments will lead you to ask questions *you might not yet be able to answer*. The main thing at this stage is that you are asking questions, and this is an important thing that scientists do.

EXPERIMENT 1

What happens when you burn a tin full of gas?

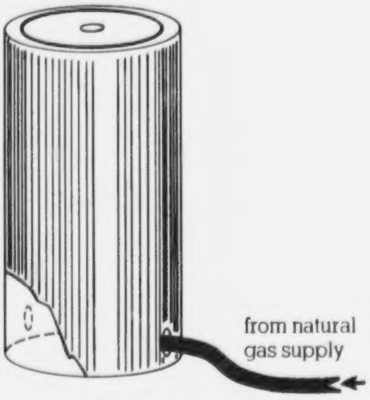
For safety reasons this experiment should be carried out by your teacher as a demonstration.

Safety! This experiment should be demonstrated away from any electric lights. Don't stand near the tin.

You Will Need:

- An empty tin with lid (e.g. a coffee tin)
- A length of rubber tubing to attach to gas supply
- Matches
- A drill

Steps to Take:



1 Drill two 20 mm holes near the base of the tin and a 10 mm hole in the lid as shown in the diagram.

2 Attach one end of the rubber tubing to the gas tap and place the other end in one of the holes near the base of the tin.

3 Tightly fit the lid to the tin. Place a finger over the hole in the lid. Turn on the gas and allow the tin to fill with gas. Check to see if the tin is full by lifting your finger from the hole and replacing it at once. If full, you will get a strong gas odour.

Safety! Don't breathe the gas directly. Waft it over with your hand.

4 Ignite the gas flowing out through the hole in the lid.

5 What do you think will happen if you turn off the gas supply and remove the rubber tubing from the hole in the bottom of the tin?

6 Now try it, quickly **stand back** and observe what happens.

(a) What did you observe?

(b) Was what you observed the same as what you thought would happen?

(c) Record any ideas you have which might explain what happened.

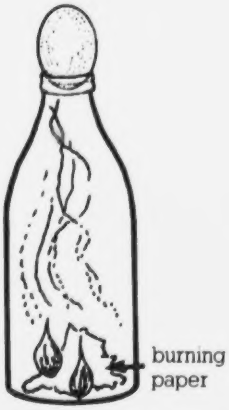
EXPERIMENT 2

How can an egg be put inside a bottle?

You Will Need:

- A hard-boiled egg (about 50 g)
- An empty glass milk bottle
- A small piece of paper (about 5 cm square)
- Matches

Steps to Take:



1 Remove the shell from the hard-boiled egg and place the egg on the mouth of the milk bottle.

2 Write down what you think will happen if a piece of burning paper is put into the bottle with the egg placed on the mouth of the bottle.

3 Light a small piece of paper. Quickly lift up the egg and put the burning piece of paper into the bottle. Immediately place the egg back on to the bottle's mouth. Record what happens.

4 (a) Why do you think the egg fell into the bottle?

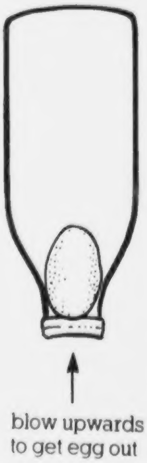
(b) What did the burning paper do to the air inside the bottle?

(c) What did the egg do before it fell into the bottle?

5 Write down how you think you might be able to get the egg out of the bottle.

6 Now try to get the egg out of the bottle.

7 If your methods did not work, turn the bottle upside down and let the egg fall into the bottle neck. Blow short spurts of air from your mouth up into the inverted bottle and catch the falling egg.


blow upwards to get egg out

8 Explain what happened when the egg went into the bottle and then fell out again.

EXPERIMENT 3

What happens to strips of celery when you put them into water?

You Will Need:

- Two sticks of celery
- A knife or scalpel
- Two 250 mL beakers of water

Steps to Take:

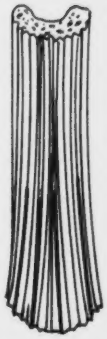
1 Cut the celery crosswise into pieces about 6 cm long and then lengthwise into strips as narrow as you can

cut them. Put the celery strips into a beaker of water. What do you think will happen?

2 Try doing the same thing cutting the celery as shown in the diagram. Put it into the other beaker.

3 Leave the celery for about 20 minutes and then record what you observe.
Continue with the next experiment while you are waiting. Then return to step 4.

4 (a) What happened to the celery strips after they had been in water for a period of time?
(b) Why do you think this happened?



EXPERIMENT 4

How can you pick up an ice cube using salt and thread?

You Will Need:

- An ice cube
- A 250 mL beaker of cold water
- A piece of thread
- Some salt in a salt shaker

Steps to Take:

1 Let the ice cube float in the full beaker of cold water.

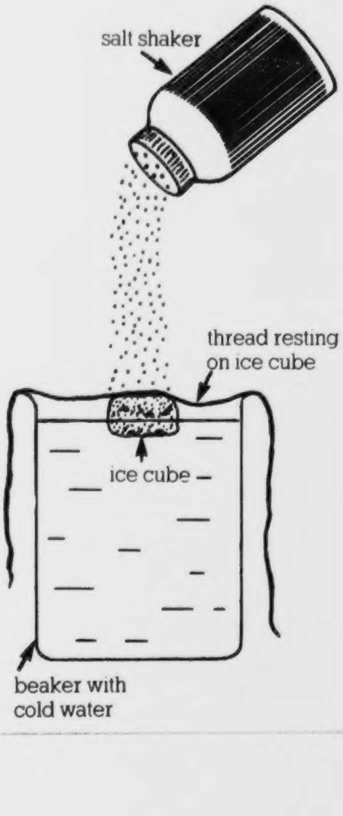
2 Write down some possible ways of using the salt and thread to lift the ice cube of the water.

3 Lay the thread across the ice cube. Sprinkle salt on to the thread.

4 Wait about two minutes and slowly lift up the thread at both ends.

5 Record what you observe.

6 Write down any ideas you might have to explain what you have observed.



In the next experiment you will be using the Bunsen burner. It is a piece of equipment commonly used in most laboratories. So let's take some time to see how we can use it safely.

Using the Bunsen burner

Practice using the correct procedures.

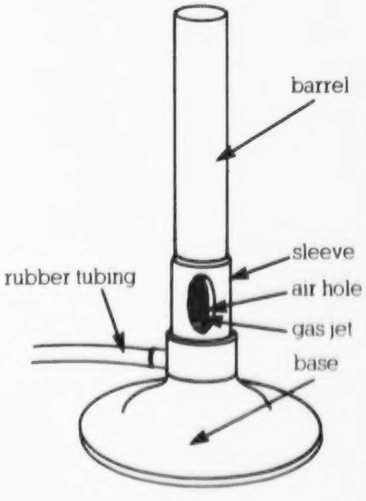
You Will Need:

- A Bunsen burner
- A box of matches
- A heat-proof mat

Steps to Take:

1 Place the burner on the heat-proof mat.
If a lighter burner is accidentally knocked over onto the mat, the bench is less likely to be damaged. We use a heatproof mat for any apparatus while it is cooling.

2 Look at the diagram showing the main parts of a Bunsen burner. Make sure that you can find these parts on your burner.



3 Connect the burner with rubber tubing to the outlet of the gas tap.

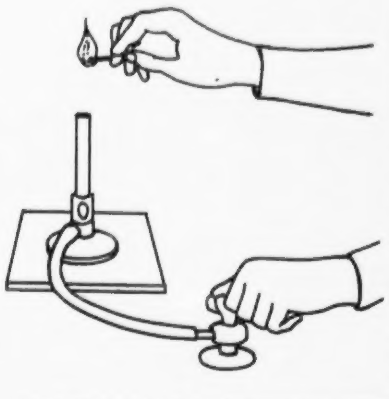
Safety! Make sure that all the fittings are firmly connected.

4 Light the burner by following these steps:

Safety! Keep your head away from the Bunsen burner when lighting it. Make sure any loose hair is tied back.

- First light a match and hold it **away** from the burner.
- Then turn the gas full on and bring the match to the top of the barrel.

If a hissing noise comes from the burner, or a flame burns at the jet, **turn of the gas immediately**. The burner

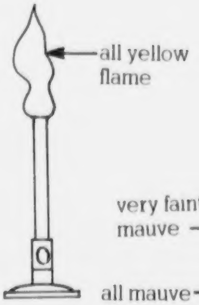


is said to be **burning back**. Report this to your teacher. The burner may need cleaning.

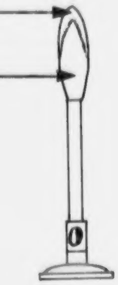
Look again at the diagram showing the main parts of the Bunsen burner. You will notice that the burner has an air hole. You can control the size of the air hole by moving the sleeve.

5 Find out what happens when you turn the sleeve through one rotation. Notice the position of the sleeve and the size of the air hole for each sort of flame.

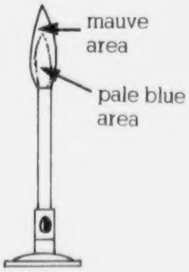
Now let's check on this.



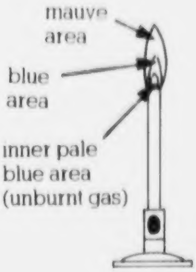
When the air hole is closed, the flame is yellow. We adjust the burner to a yellow flame when we are not using is, so that it can be clearly seen.



When the air hole is just open the flame is a mauve colour. We use this flame for very gentle heating.



When the air hole is half open the flame is still mauve but it has an inner pale blue area. This flame is hotter that the mauve flame.



When the air hole is completely open we have the hottest flame. This flame shows three colours, mauve, blue and pale blue but they are not always easy to see. Be careful when you are looking for them.

What is happening?

As the gas from the gas jet comes out of the rubber tube and rushes past the air hole, air is drawn into the burner. It is this mixture of air and gas that burns at the top of the barrel. The more open the air hole is, the more air can be drawn in the hotter the flame is.

EXPERIMENT 5

Can water be re-boiled without heat?

You Will Need:

- A 250 mL or 500 mL round-bottomed flask with stopper
- A Bunsen burner
- A retort stand and clamp
- Matches

Steps to Take:

1 Half fill the round-bottomed flask with water.

2 Heat the water in the flask until it boils.

3 Remove the flask from the heat source and stopper the flask.

4 Cool the outside of the flask with cold water.

5 Describe what happens. How can you explain your observations?

You have now completed some introductory experiments and have asked some questions.

Now it is time to look more closely at what being a scientist means.

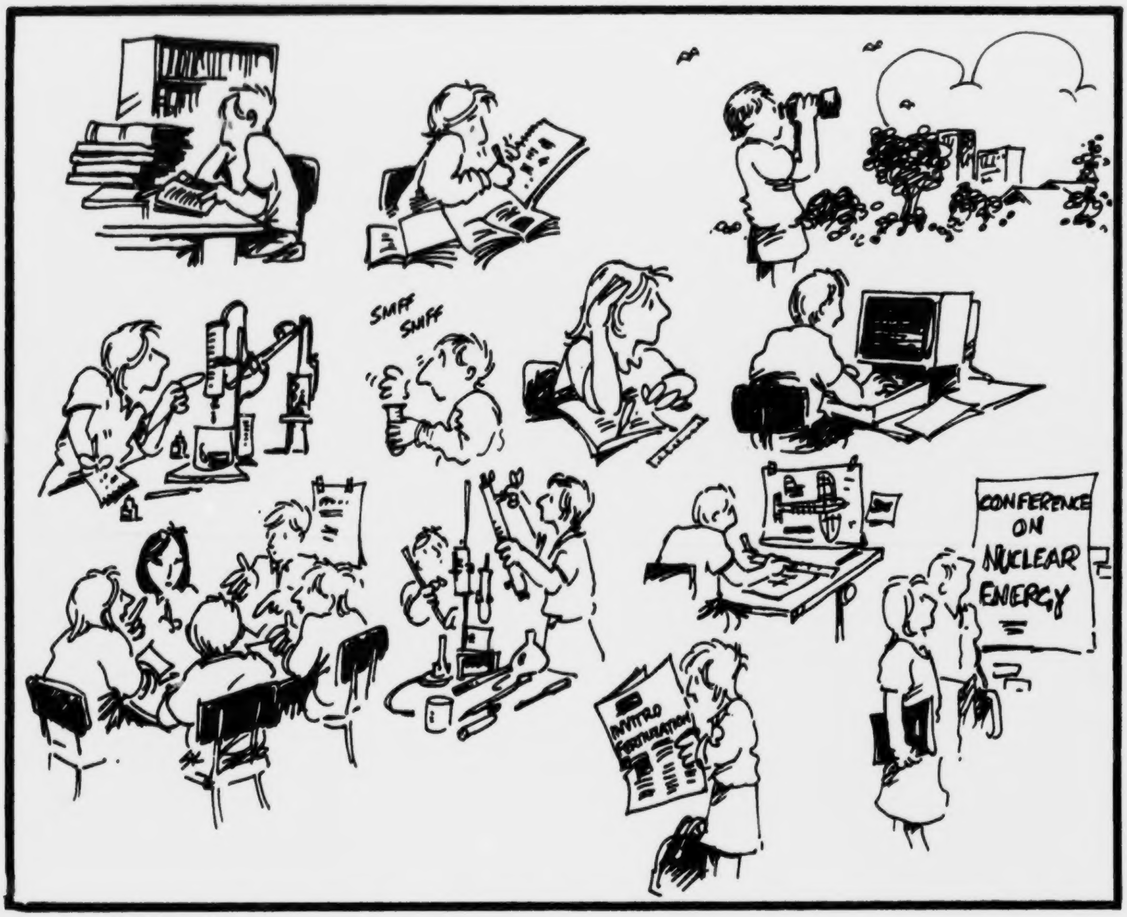
SCIENTISTS

We want to find out what the scientist in you is like. Let's start off looking at what scientists do.

ACTIVITY 1

What do scientists do?

1 Look at the illustrations on the next page. Use them to help you write a list of what scientists do.



2 Think of news reports about scientists or scientific discoveries. Does this help you to add to your list?

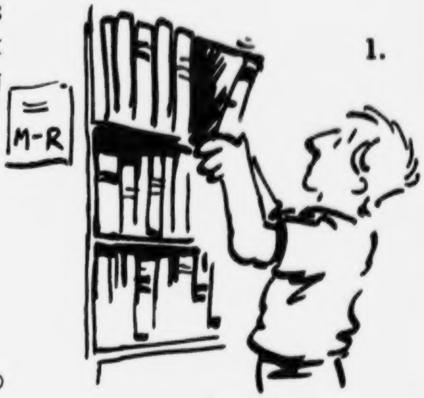
3 Check your ideas with a partner. Add to your list if you can.

4 During the next two weeks check your newspapers and other magazines you have at home. Choose three different short articles that discuss something about science. After you have read them, paste them in your notebook.

5 You could organise a class resource file: collect materials from the CSIRO, and pamphlets from the SEC, government departments and others. Organise yourselves into groups. Each group can contact a different organisation for further information about the work their scientists do.

We have started to look at what scientists do. Scientists try to answer questions and solve problems. Let's think about how you solve a problem. We can say that solving a problem involves:

1. checking resources
2. close observation
3. the listing of details
4. reflection (thinking – linking observations)
5. arriving at explanations (reaching a conclusion)



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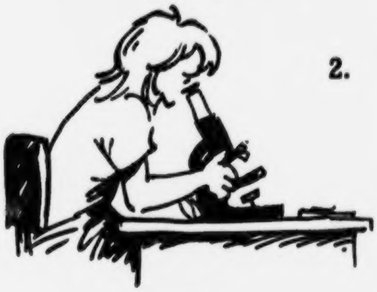

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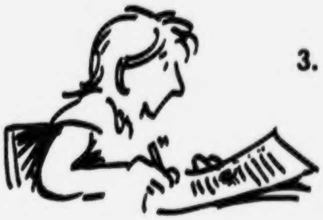

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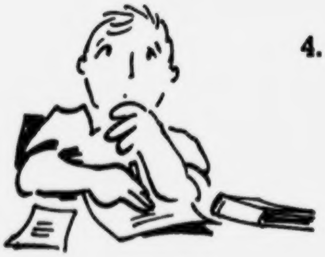

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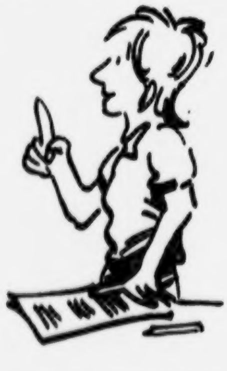


5.

We will be looking more at problem-solving as we go through this chapter.

Now it is time to set to work. Select one of the problems below and then try to solve it. You can look back at the problem from time to time as you go through this chapter. You may get some ideas on the way.

ACTIVITY 2

Can you solve this problem?

1 Work in pairs and select one of the following problems to look at:

- What ways can be used to measure the length of a lesson?
- Which is heavier – a frozen pie or a fresh pie?
- How many different animals live in one plant?
- What is a suitable height for a classroom chair?
- How does a ball-point pen work?
- Why are there four seasons?

Or your teacher may help you to choose a similar problem.

2 Keep a daily record of your ideas and the ways you attempt to solve the problem.

3 At the end of this chapter your teacher might like you to give a verbal report to the class.

So far you have considered some of the things that scientists do, such as checking resources, observing, reflecting, and arriving at explanations. You have also selected a problem to solve and to talk to the class about.

Now it's time to look in more detail at using resources.

USING RESOURCES

As a scientist you usually set about looking at a problem by first using your own resources. You work out what you:

- know for sure about the problem;
- are not so sure about the problem; and, therefore,
- what information you need to find out.

ACTIVITY 3

Can you use your own resources?

Steps to Take:

1 Let's look at the question you selected as your problem in Activity 2. Write down the things you are sure about, the things you are not so sure about and the information you need to find out. Write your ideas on a table like the one below.

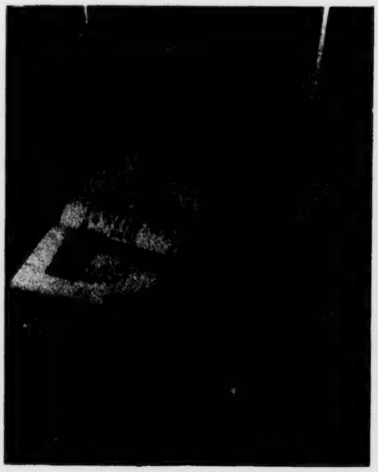
Things I'm sure about	Things I'm not sure about	Things to check on

2 Discuss with your partner what you have worked out. You may get some more points to add to your lists.

When you are clear about what information is required, you have to consider where to search for relevant information. The school and local libraries provide important resources for you.

ACTIVITY 4

What information can you get from television and radio?



What do you think this student is researching?

In this activity you will concentrate on finding information from a science book. Your teacher or librarian will show you where you will be able to find these books in your school or local library.

Answer one of the following questions by using science books from the library:

- What happens to tadpoles as they grow bigger?
- What happens when metals are heated?
- How can we stop people getting measles?
- Why are we told that fibre is so good for us?

Steps to Take:

1 Think of the main subject of information related to the question you have chosen. For example, if you chose the first one, the main subject could **tadpole**. It could also be worth checking **growth**.

2 Ask your teacher or librarian to show you how you can look up information in the subject catalogue. Remember that a good dictionary and a good encyclopedia can often be useful.

3 Look up these subjects in the index at the back of a book to find out which page(s) contain relevant information. The information you find may lead you to look up other related topics.

4 Make a list of three books which will be useful references for you. For each, write down the author (or editor), the date of publication, the title, the publisher, the place of publication, and the relevant pages. For example:

Jones, A. (1986), Your Life in Their Hands, Maki Press, Melbourne, pages 24–26, 67–69.

Why do you think it would it be useful to record this information?

5 Select some headings to help you organise the information you find in the books. Record what you

have found in a table like the one below. This table is based on the question – 'What is the difference between a sea anemone and a crab?'

Questions	**Sea anemone**	**Crab**
Animal or plant? *Where does it live?* *How does it feed?*		

6 Write one or two paragraphs containing the information you have on your table.

You can now use the library in a similar way to help you look up any information you require for the problem you selected from Activity 2.

Information from other sources can also be very useful. For example, your library may have newspaper cuttings, video tapes or computer discs you could use. People can also be a good source of information.

ACTIVITY 5

What information can you find in books?

Work in pairs.

Steps to Take:

1 Look through a television or radio guide and each select a different science programme you will be able to look at or listen to before next lesson.

2 When watching or listening to the programme, make a special effort to concentrate on at least the first ten minutes. Make some notes to remind you of what it is about.

3 During the next lesson describe what the programme was about to your partner.

4 Work out with your partner a way in which you might rate the programmes. Then you can each rate your programmes on the same scale.

In this section you have thought about the various places where you can find information you need. Libraries contain librarians, books, newspapers and computer discs. Other people can help you answer some of your questions, and television and radio are also valuable sources of scientific information.

For a particular problem you have worked out:
(a) the things you are sure about
(b) the things you are not sure about
(c) the things you need to check.

FINDING OUT ABOUT EXPERIMENTS

Scientists look at the world around them very carefully. They look for patterns, changes and clues to tell them why things happen. Scientists are very curious people – they investigate and explore the world in which we live.

Babies do exactly the same thing. They learn more about their world by always watching, touching, tasting and listening. In other words, they learn by using their senses to give them information which they store in their memories. How do *you* learn?

What is this baby up to?

Making observations and recording the results

Your senses also help you investigate the world around you. In Chapter 3 you will be able to learn more about your sense of taste, smell, hearing and touch. Scientists use all these senses to observe things. **Making observations** is very important in science. Scientists need to be able to notice very small details.

Now we will concentrate on **sight**. How carefully do you watch things that happen around you?

ACTIVITY 6

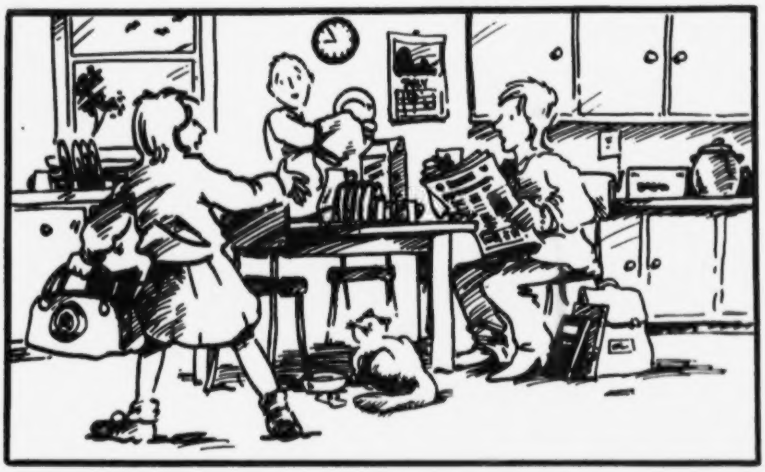
What's the difference?

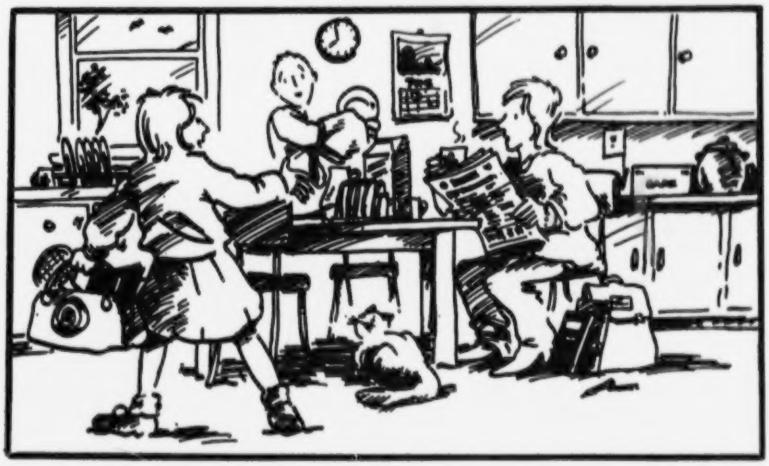
In this activity you can test how observant you are. Firstly, you can try your skill at comparing some pictures of everyday activities, and then you can apply your skill to a scientific activity.

PART I Comparing Pictures

Steps to Take:

1 Look closely at the following illustrations.





2 Write down all the differences you can see between the two pictures.

3 Compare your observations with your partner.

Now let's see how you go with comparing plants.

PART 2 Comparing Parts of Plants

You Will Need:

- Two different leaves
- Two different flowers
- A hand lens

Steps to Take:

1 Make a list of differences between the two leaves and a list of any ways in which you think they are the same.

2 Do the same with the two flowers.

3 Compare your findings with your partner. Perhaps there are some extra points you could add to your list.

Sometimes scientists use equipment to help them make observations. In the next activity you can think a little about this.

IT'S AN ELEPHANT I THINK...

ACTIVITY 7

What instruments do scientists use?

1 List some instruments that help scientists make observations about details that are small. Compare your list with your partner's list.

2 Pick two different instruments from your list and look up some further information about them in the library. Write a paragraph about each of these. You could include information about:

- who first used the instrument
- what it was used for
- what discoveries were made with it

You have now made observations and recorded them so that they will not be forgotten. Scientists do this all the time. It is called **recording the results** of an investigation. Scientists record things so that they will not forget what they have done or learned.

ACTIVITY 8

How accurate are your descriptions?

Work in pairs.

You Will Need:

- Any simple piece of apparatus you use in the laboratory, but don't show your partner what you have chosen.

Steps to Take:

1 Without showing your partner, describe the piece of apparatus as accurately as you can. Don't name it.

2 After listening to your description, your partner should try to draw what he or she thinks it is.

3 Look at your partner's drawing. How accurate was your description? If your partner managed to identify the apparatus in general, how accurate were they in the detail (size, colour, shape)? Correct any errors and name the item.

4 Why is it important for you to describe accurately? Give some specific examples of when this might be important for scientists.

Testing hypotheses

When scientists have a question, they think of an experiment which may help find the answer. A scientist often makes a guess at the answer before starting the experiment – this guess is called a **hypothesis**. Then the scientist will use the experiment to test whether the hypothesis (guess) is correct or not. You can do this too. Consider a general question and then make some hypotheses (guesses) at what the answers might be.

Here is a question – How do you get more energy to parts of your body when you run faster?

Write down ways in which you think you get more energy for running faster. These are your guesses or hypotheses.

Some of your hypotheses might be:

- You don't, the muscles have plenty of energy in them.
- Blood is pumped through the body faster.
- You think about running and the brain supplies the energy.
- You breathe faster.
- You breathe more deeply.

Let's do an experiment to test one of the hypotheses we thought of, namely, that *blood is pumped through the body faster during exercise.*

EXPERIMENT 6

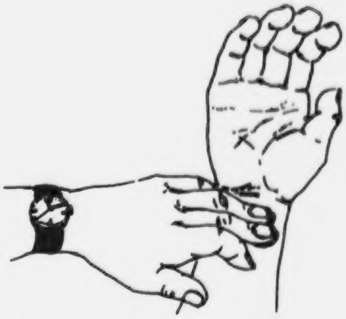
How does the heart rate change when you exercise?

Work in pairs.

Safety! This activity involves strenuous exercise. If for any medical reason you cannot take part in this activity, make sure that you act only as recorder.

The rate at which blood is pumped around the body by the heart can be found by taking the pulse. The pulse is the rhythmical throbbing of the arteries as blood is pumped along them. You should be able to find your pulse most easily in your wrist.

Use your fingers, not your thumb, when taking a pulse reading.



You Will Need:

- A watch showing seconds, or a stop watch
- A stool, box or chair 30–40 cm high

Safety! Make sure the chair or box is stable.

Steps to Take:

1 Working in pairs, count your partner's pulse rate over 30 seconds while he or she is seated. Make a note of the number of beats, for example, 30 beats per 30 seconds.

2 Double the number to find out how many pulse beats that is per minute. Record this number in your notebook. This is your resting pulse rate.

Subject	**Pulse rate in beats per minute**	
	Sitting	After exercise
Jason Karla		

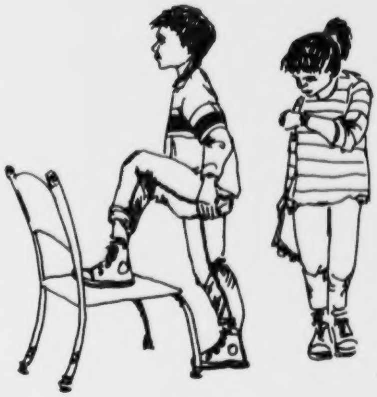
3 Get your partner to do some exercise. It need not be too long but it needs to be fairly vigorous.

It also needs to be the same exercise that you will do for the same amount of time when it is your turn. Here is a suggestion:

Use a chair to step up on and down from for three minutes. Practise stepping up and down on the chair. Get the rhythm of your feet going – one foot up, other foot up, one foot down, other foot down. Make sure the stool is secure and steady. You should straighten your legs each time you stand on the chair and both feet should be placed on the floor when you step down.

Each person needs to develop the same rhythm and way of doing it.

4 As soon as your partner has completed the stepping exercise for three minutes, take his or her pulse immediately over 30 seconds. Double the result so that you know how many beats there are per minute.



5 Now swap places. Record the results for 3 other members of the group.

6 (a) What were the resting heart rates? Were they the same for each person?
  (b) What were the heart rates after exercising?
  (c) Why do you think it may be more accurate to take the pulse within the first thirty seconds after exercise?
  (d) Why do you think that it was important that you and your partner did the same kind of exercise?
  (e) What is the effect of exercise on the heart rate?
  (f) Why does your heart pump faster – more beats or pulses per minute?
  (g) Does your breathing become deeper or faster? Why? You might like to check this in another experiment.
  (h) Look back at the hypothesis. What did your findings from this experiment tell you about this hypothesis?

ACTIVITY 9

Want to try out some other hypotheses?

Steps to Take:

1 Look back to the hypotheses that you thought of for the question on page 18.

2 Work out a way in which you could test one of these hypotheses.

3 Discuss your ideas with a partner.

4 Try testing one of your ideas.

Recording

Scientists make sure they will not forget by making a written **record** of their experiments. The main things recorded are:

- the hypotheses
- the equipment and materials
- the method of carrying out the experiment

- a description of the result
- the conclusions – what was learnt from the experiment about the hypothesis.

Sometimes the experiment might reveal new problems that you would like to solve. Make a note of them.

Sometimes you may use diagrams when you make your records. Occasionally, you may record by other means such as photography or video-recording.

In Appendix 1 you can see a way of writing up an experiment. At this stage it is more important that you learn to record your observations and conclusions in your own way.

So, scientists learn to make observations, and careful descriptions of what they see. They make hypotheses, conduct experiments and record their results.

MEASURING, GRAPHING AND AVERAGING

The observations scientists make often involve them in taking measurements. Now's the chance for you to do some more measurement.

ACTIVITY 10

How tall are you?

How can you find out how tall a person is? The answer is to measure them. In this next activity you can measure each other and find out how tall you all are. Work in pairs.

You Will Need:

- A roll of toilet paper
- Scissors

Steps to Take:

1 Take a roll of toilet paper and unroll it until it reaches from the floor to the top of your partner's head.

2 Use the scissors and cut the toilet paper so that it is the same height as your partner. Hold it straight but don't stretch it. Write your partner's name on the top of the toilet paper.

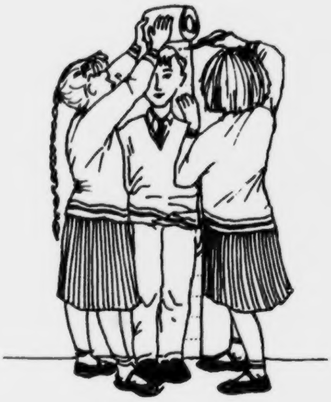
3 Now ask your partner to measure you in the same way.

4 Count the number of sheets you have used to measure your heights. (Count to the nearest half sheet.) How many paper sheets high are you?

5 (a) How many sheets high is the tallest person in the class?

(b) Compare your height with the height of everyone else in the class. What is the most common height in your class (to the nearest half sheet)?

6 Keep your sheets for the next activity.



ACTIVITY 11

How can you compare your heights?

You Will Need:

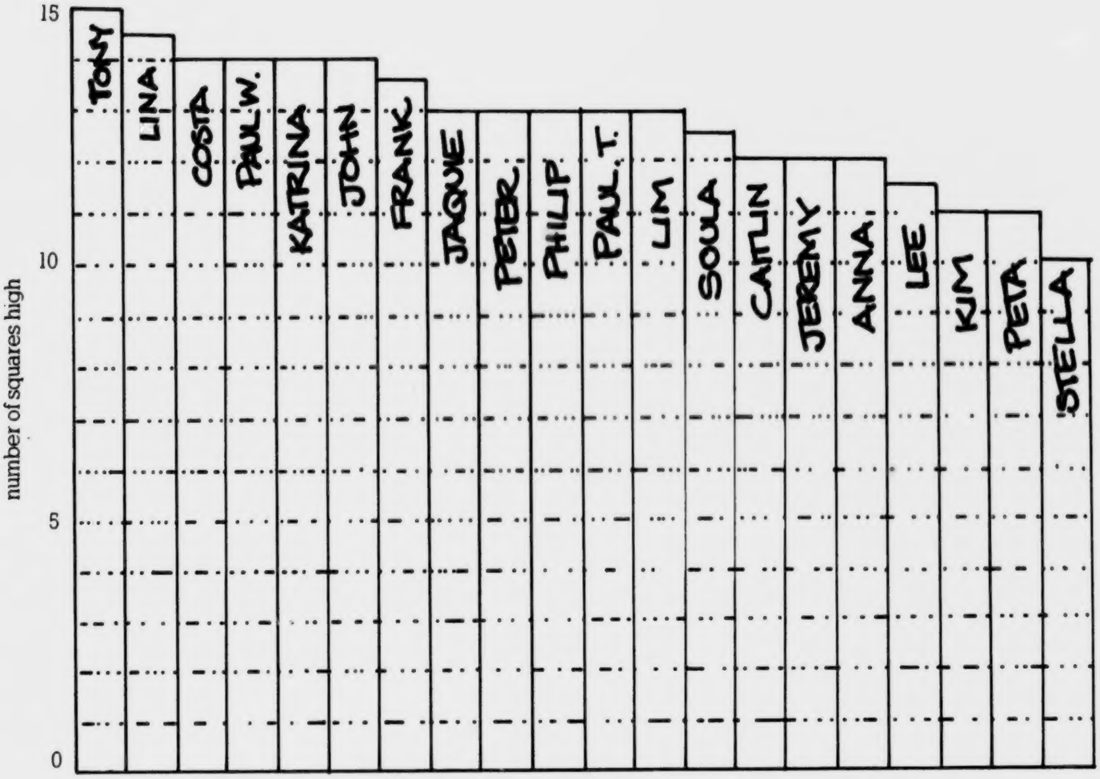
- The length of toilet paper which represents your height from the last activity (Activity 10)
- Sticky tape
- A bare wall about three or four metres wide

Steps to Take:

1 Start with the piece of toilet paper belonging to the shortest person in your class. Stick this piece of toilet paper on the wall so it just touches the ground.

2 Now stick the paper belonging to the next tallest person next to it, and so on, until everyone has stuck their paper on the wall.

3 Draw a picture of the toilet paper heights of all the people in your class.



4 Label your picture as shown above in the diagram.

The diagram you have made shows the height of everyone in your class. This sort of diagram is called a **graph**. It helps you to compare information easily. In this case, it helps you compare the heights of people very easily. Your wall of toilet paper is actually just a large graph.

To work out the **average** height of a group of people, you add the heights together and divide by the number of people in the group. For example, to find out the average height of a group of four people, add their individual heights together, and then divide the total by four.

ACTIVITY 12

What is the average height of your group?

Work in groups of four.

You Will Need:

- A roll of toilet paper
- Sticky tape
- Scissors

Steps to Take:

1 Measure the height of each person in your group by using lengths of toilet paper.

2 Join the four pieces of toilet paper together to make one long strip. This long strip will be equal to the height of your group joined together. (If you stood on each other's head this is how high you would reach.)

3 Fold this long strip in half.

4 Fold it in half again. It should now be in quarters.

5 How many sheets long (to the nearest half sheet) is each quarter?

This is the average height of your group.

6 You could now try to find the average for the whole class. This will test your organisational skills!

If you made a human pillar by standing on each other's heads, how tall would the pillar be? Join your toilet paper to find out. Then fold the paper into as many equal sections as there are people in your class to find the average.

You have just finished measuring yourself and other class members using squares of toilet paper. Each sheet of toilet paper was a **unit** of measurement.

ACTIVITY 13

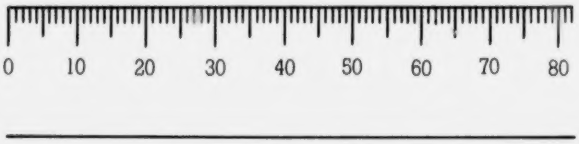
Do you know how to measure length, area and volume?

Work in pairs.

You Will Need:

- A ruler
- A tape measure

Reminder! Check that you are measuring from the zero line.



Steps to Take:

1 Practise measuring some objects around you. Draw up a table and record the dimensions (height, length and breadth) of everything you measure.

Object	Height	Length	Breadth

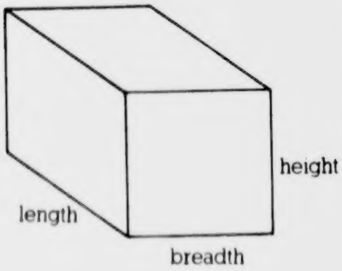
2 Show your partner the objects you measured. Then see if your partner can identify each object from the measurements you recorded on the table. Make sure you cover the names of the objects on your table before you show your partner the measurements.

3 Work out the area of the flat side of your textbook or your notebook. (You can find the area of a rectangle by multiplying the length by the breadth.)

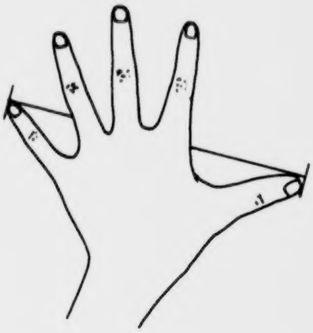
4 Work out with your partner how you can estimate the area of the school grounds. Compare your results with those of other groups. How could you be more accurate?

5 Work out the volume of your textbook. (You can find the volume of a rectangular prism by multiplying length by breadth by height.)

6 How could you work out the volume of an irregular solid?



ACTIVITY 14
What about other units of measurement?



1 Measure your partner's height in handspans.

2 Think of occasions when people take measurements in their daily lives.
Make a list of units of measurement you use every day.

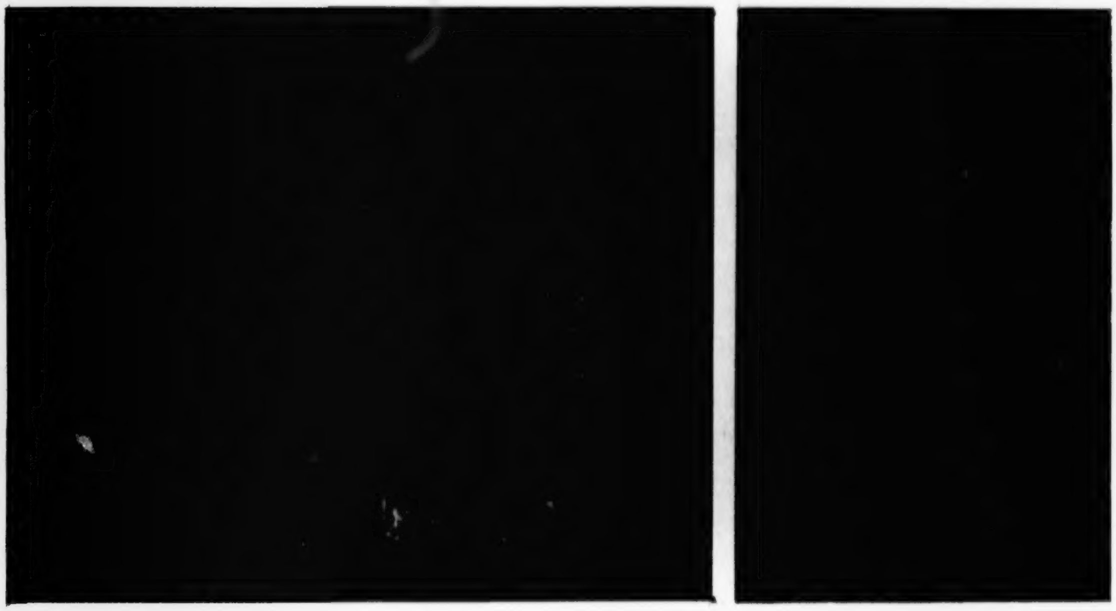
SAVOY
MILK
"The easy entertainer"

You could do the following activity for homework.

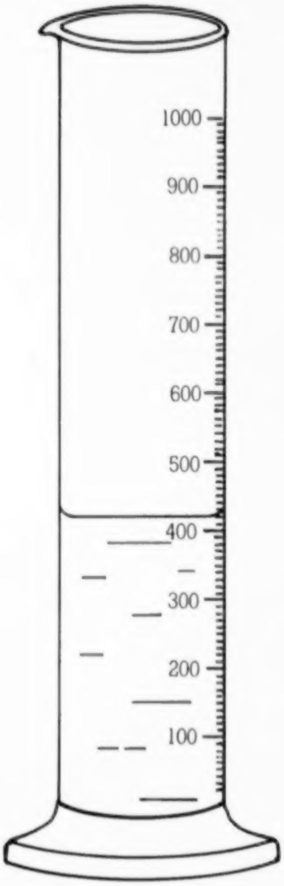
ACTIVITY 15
How do we measure time?

Steps to Take:

In this activity you can use an encyclopedia and other resources in the library to find out how people have measured time in the past. Write a paragraph about each of the major developments you find out about.



What would it be like to be without a watch?



People use units of measurement every day. Think of your ruler. Units are usually joined together to make a scale. We use scales to help measure things. Look at the graduated markings on the measuring cylinder in the diagram. These markings are a **scale.**

Measuring the volume of a liquid

Liquids are measured by volume. This means 'how much space they take up'. The units used to measure the volume of liquid are called millilitres (mL) or centimetres cubed (cm^3 that is, cm × cm × cm). The most commonly-used unit is the millilitre.

Water is the most common example of a liquid, and a very important substance. We need to drink it regularly to remain healthy. Do you know how much water you drink each day? How could you work it out?

When we measure the volume of anything, we use a **scale**. Let's make a scale.

ACTIVITY 16

How can you make a scale?

We can use a test-tube of water as a unit of measurement.

You Will Need:

- A test-tube
- An ungraduated jar or cylinder
- A texta

Steps to Take:

1 Carefully fill the test-tube full of water and pour it into the cylinder or jar.

2 Make a mark showing the level of the water in the cylinder with your texta.

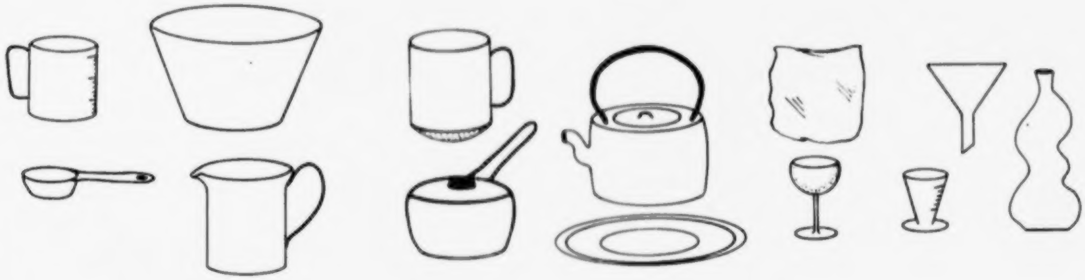
3 Continue adding full test-tubes of water to the cylinder or jar. Mark the level each time.

Now you have a scale. The scale is based on test-tubefuls of water. Imagine that the test-tube was 10 mL in volume. You would then have made marks every time you added 10 mL of water.

4 Choose some beakers and measuring cylinders. Use your scale to measure their volume.

ACTIVITY 17

Do you know how to measure liquids?

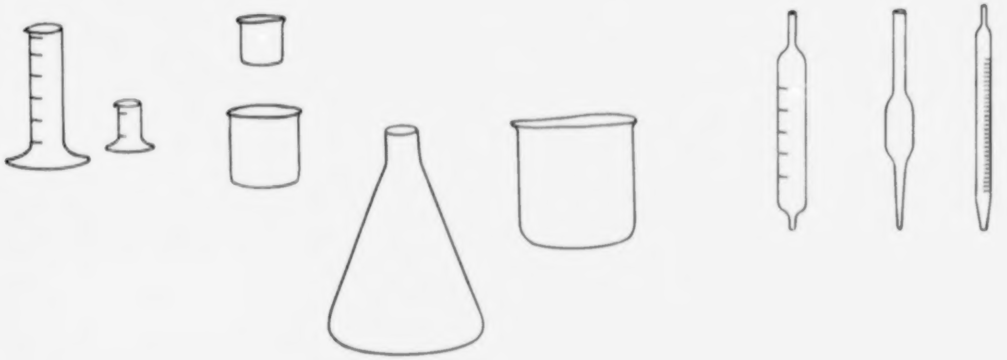


Look at the picture above.

1 Which of the objects shown could you use to measure water?

2 List seven containers you have at home to measure liquids. Which of these are the most accurate? Which are most commonly used?

The picture below shows some of the scientific equipment used in a laboratory to measure liquids.



Do all the containers have scales?

3 Make a list of the equipment you could use to measure the volumes of liquids.

4 When you are home, make a list of things which have their volume written down in millitres or litres on their labels.

ACTIVITY 18

How do I read accurately?

You Will Need:

- A 100 mL beaker
- A 100 mL glass measuring cylinder
- Four 10 mL cylinders
- A 250 mL beaker
- Water, oil, kerosene and other liquids

Steps to Take:

1 Fill one of each type of container with water up to the top line on their scales. Look carefully at the surface of the liquid from the side.

2 What shape is the surface of the liquid? It is best seen in the measuring cylinder. Draw it.

3 Fill the three other 10 mL measuring cylinders with the other liquids – oil in one, kerosene in another and so on.

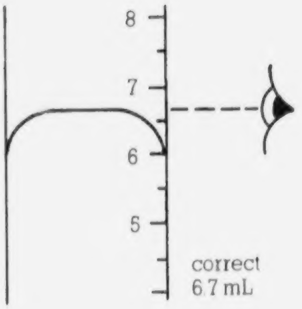
4 Draw the shape of the surfaces of these liquids.

5 Are the surfaces all the same shape?

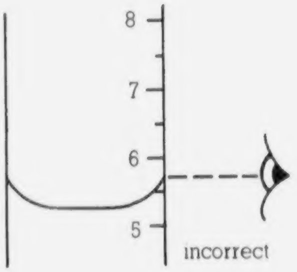
Check all your drawings and look very carefully at the tops of the liquids. Do you notice that the surface always seems to have a curve in it?

This curve in the top surface of the liquid is called the **meniscus**. You should always take a reading with the meniscus at eye level, and read from the most curved part of the meniscus just as in the diagrams below.

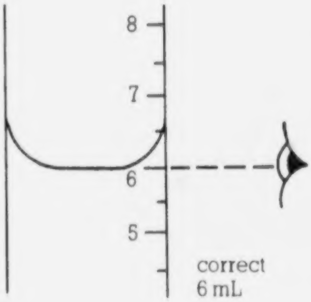
For example, for water your eye should be level with the bottom of the meniscus.



correct
6.7 mL



incorrect



correct
6 mL

ACTIVITY 19

Which container measures 5 mL most accurately?

You Will Need:

- A 100 mL beaker with a scale
- A 100 mL measuring cylinder
- A 10 mL measuring cylinder
- Coloured water

Steps to Take:

1 Read the scale on the 100 mL beaker. Fill the beaker with coloured water up to what you judge to be the 5 mL mark.

2 Do the same thing using the 100 mL measuring cylinder.

3 Pour the water you have measured in the beaker into the 10 mL measuring cylinder. Record the actual measurement.

4 Do the same for the water measured in the 100 mL measuring cylinder.

5 Which container appears to measure 5 mL more accurately?

6 Which of the three containers would you chose if you had to measure and take 5 mL of medicine? Explain why.

7 If you had to use exactly 50 mL of water to mix some paint, which of the three containers would you then choose? Explain why.

EXPERIMENT 7

Can one and one make two?

What will happen if you add one volume of water to an equal volume of methylated spirits? Write down your prediction.

You Will Need:

- A 100 mL measuring cylinder
- A 100 mL beaker
- Methylated spirit

Safety! Don't have any naked flames nearby when you use methylated spirits. It is inflammable.

1 Use the measuring cylinder to pour a measured amount of methylated spirit into the beaker. Then add the same amount of water to the beaker.

2 Record your observation.

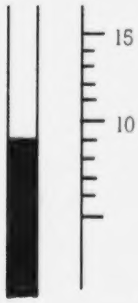
3 Write down any ideas you have which explain your observation.

4 Discuss your ideas with a partner.

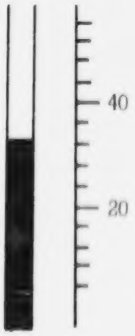
Let's measure something else using a scale.

Temperature is the level of heat in a body. People usually use **thermometers** to measure temperature. A thermometer has a scale written on it. Each unit or division on the scale is equal to 1°C in temperature. A thermometer sometimes has mercury in it – many will now have alcohol. But whichever liquid it is, it is important to realise that it expands when heated.

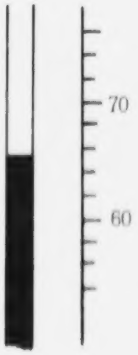
Read and record the temperatures on the thermometers shown below.



A



B



C

ACTIVITY 20

What is your body temperature?

It would be preferable to work in pairs.

Safety! Don't put a laboratory thermometer in your mouth.

You Will Need:

- A clean thermometer

I'VE GOT A FEVER!

Steps to Take:

1 Take your thermometer carefully out of its case. Hold the thermometer at the top. Do not hold it at the base. Why?

Safety! Place the thermometer on the bench so that it will not roll off. If you should accidently break a thermometer report the accident to your teacher immediately.

2 Leave the thermomometer for 2–3 minutes.

3 Read the room temperature off the scale. Record the temperature in your notebook.

4 Now, while watching the level of mercury in the thermometer, place your hand around the bulb of the thermometer.

5 (a) What happens to the level of the mercury?
(b) Does the mercury stop?
(c) How hot is your hand?
Record the temperature of your hand.
(d) What is the difference between the temperature of your hand and the room temperature?
(e) What happens to the level of the mercury when you take your hand off the thermometer?

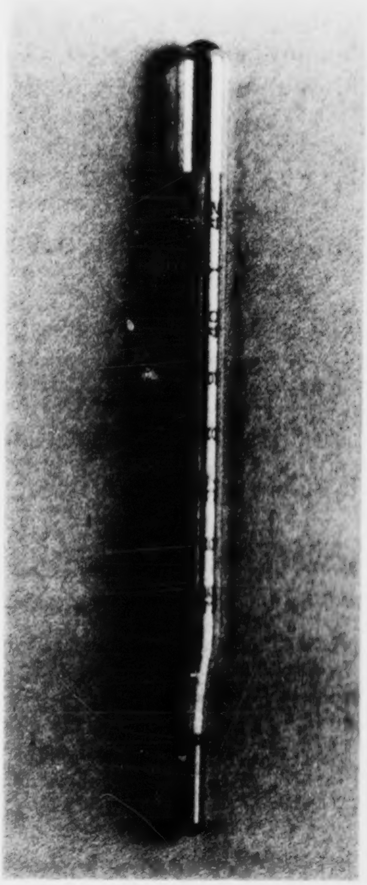
6 Place the end of a clean thermometer under your bare armpit. Leave it there for 3–5 minutes.

7 Ask your partner to read the thermometer while you keep it under your arm. If you remove the thermometer to read it, the temperature will drop.

8 (a) What was the temperature of your armpit?
(b) How did the armpit temperature compare with the hand temperature?
(c) Tabulate the results for a number of people. What do you conclude from your findings? Is there much variation? If so, how do you explain it?

9 Discuss your findings with your partner.

Remember the thermometer your parents use when you get sick? It is called a **clinical thermometer**.



What do you notice about the mercury column near the base of the thermometer? Write down your observations.

EXPERIMENT 8

How do you compare thermometers?

You Will Need:

- A clinical thermometer
- A laboratory thermometer
- A container of warm water (You need it about 40°C– that is, not so hot that you can't leave your finger in it!)

Steps to Take:

1 Place both thermometers in warm water for 1–2 minutes.

2 Read and record the temperature of the clinical thermometer. Take the thermometer out of the water, count to 20 and read the temperature again. Record that temperature also.

3 Read and record the temperature of the laboratory thermometer. Take the thermometer out of the water. Count to 20 and read it again. Record that temperature also.

4 (a) What happened to the temperature of the clinical thermometer after you had counted to 20?
  (b) What happened to the temperature of the laboratory thermometer after you had counted to 20?

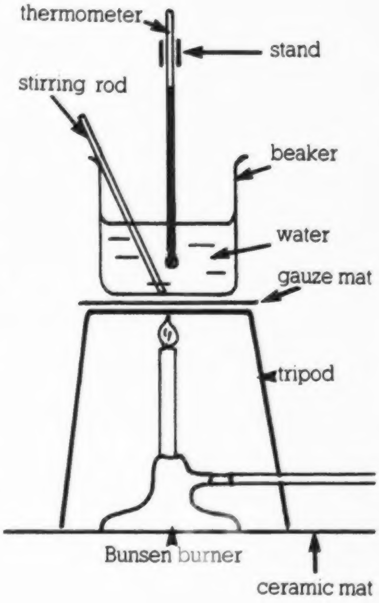
5 Shake the clinical thermometer. Take care not to drop the thermometer while shaking it.

6 Record what happened to the mercury or alcohol after you had shaken it. Why could the way the mercury or alcohol reacted be useful?

EXPERIMENT 9

What happens to the temperature of crushed ice when you heat it?

This is an experiment for you to try out on your own. Write a short report on how you went about the experiment and what you found out.
Hint: Mix ice with a stirring rod (not a thermometer), and read the temperature by placing the thermometer in the middle of the fluid.
You might wonder why all this information on measuring temperatures is important. So let's think about how important taking temperatures might be to us.



ACTIVITY 21

So what's so important about thermometers?

Steps to Take:

1 Think about:
  (a) some examples of where and when thermometers are used

(b) some ways in which thermometers may help us survive

(c) how thermometers are used by medical staff.

2 Use the library to check out some of your ideas. Share your ideas with your partner.

3 Write a short report, about a page long, on 'The Uses of Thermometers and Their Value to Society'?

In this section you have been measuring things as a way of recording observations. You have also worked out averages, learned to make a scale and been introduced to a way of representing results in a graph.

How can you be sure? – controlling the variables

When we do experiments it is often important for us to make sure that all the conditions are the same, except for the one we are interested in.

Let's look at this in the following experiment.

EXPERIMENT 10

How does a block of ice affect the temperature of water?

You Will Need:

- A 100 mL measuring cylinder
- Two beakers of the same size, 100 mL or 250 mL
- A block of ice

Steps to Take:

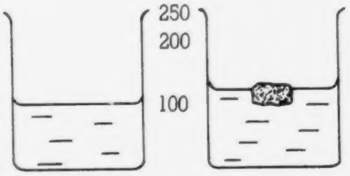
1 Measure out the same volume of tap water into each beaker.

2 Find out the temperature of the water in each beaker.

3 Make sure that the conditions are the same for each beaker. For example, don't put one beaker in the hot sun and the other in the shade.

4 Add a block of ice to one of the beakers of water. Wait until the block of ice has dissolved.

5 Measure the temperature of the water in each beaker.



You could record what you have done in a table.

	Beaker A	**Beaker B**
Size of beaker		
Volume of water		
Temperature in °C (first measurement)	water	water
Temperature in °C (second measurement)	water	water and dissolved ice

Write down what you have found out from this experiment.

For each beaker the **conditions were the same, except for the block of ice** which we added to one of the beakers.

We needed to **control** all the conditions except for one. Doing this is called **controlling the variables**. It is not easy to do, but it is the only way in which we can be sure that the results will actually show what you are interested in.

If someone had moved your beaker with the ice block in it to another part of the room where there was a draught, another variation would have been added to the experiment. If the temperature had dropped when you made your second measurement you would not have been sure whether it had changed because of the ice, or because of the draught, or because of both things.

THE USES AND INFLUENCE OF SCIENCE

Through their work, scientists have made important discoveries. Some of these have had far-reaching effects on the way we live.

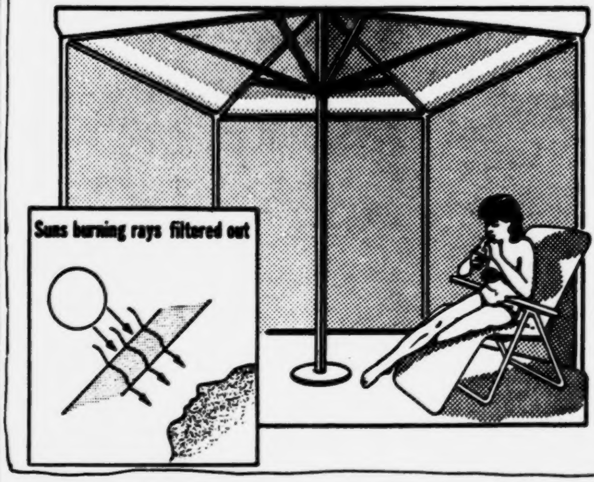
ACTIVITY 22

Want to look into the future?

Steps to Take:

1 Look at the following two articles taken from daily newspapers.

Englishmen opt for the umbravilion


Suns burning rays filtered out

GUY Belchambers, of Crusade Leisure Products, in Stratford, England, has come up with the umbravilion, a hexagonal marquee you erect like an umbrella.

As an offshoot, he has created a beach umbrella made of Solmax, which filters out 75 per cent of the sun's damaging ultra-violet B rays.

It allows 75 per cent of the sun's tanning rays to pass through.

After nine months, the products are beyond the prototype stage, and the company has hired 15 staff ready to produce them.

Damaging

Mr Belchambers has already patented the idea and the material, but is still searching for financial backing before going into full production.

Dermatologists say the umbrella, which will sell for the equivalent of $78 in Britain, should be used cautiously because the less damaging rays of the sun that still get through could cause premature ageing or abnormal freckles if absorbed in large quantities.

Test may help avoid lung, colon cancer

A TEST to measure susceptibility to lung and colon cancer has proved 70 per cent accurate in preliminary trials.

It one day may help people avoid the diseases.

Scientists say the test could have far-reaching effects on preventive medicine, but caution it is only in the early stages of development and may never be fully accurate.

Dr Ronald Pero, of the Preventive Medicine Institute-Strang Clinic in New York, developed the test, which he said eventually may identify potential cancer victims, who could then change their diets, environment and smoking habits to help prevent the disease.

"We're in the stage where we have to firm up how predictive or accurate it is," Dr Pero said.

"In three to five years, though, it could be in general use."

The test, which has been carried out on 200 patients at the Strang Clinic, involves drawing blood samples then identifying two separate enzymes that are believed to help combat colon and lung cancers.

The trial showed people with lung and colon cancer and people from families with a history of colon cancer usually had fewer of these enzymes than most of the people in a cancer-free test group.

Colon cancer has a much stronger tendency than lung cancer to run in families.

Clinicians, who did not know which blood samples were which, were able to identify those with cancer or those genetically predisposed to cancer with 70 to 80 per cent accuracy, Dr Pero said.

A biochemist at the US National Institute of Health, Dr Marshall Anderson, said: "The benefits of such a test are obvious.

"A person who is found susceptible to lung cancer would know to take preventive measures, not the least of which would be to avoid smoking."

But Dr Anderson, like other scientists interviewed, said the new test should be researched with caution. It would take years before its accuracy was established.

"People's hopes should not be raised prematurely."

Dr Daniel Miller, director of the Strang Clinic, a non-profit medical research facility, said the "ultimate test of the test" would be to track individuals found to be susceptible to lung cancer to discover if they ever developed the disease.

Dr Miller said: "Obviously that would take years and years, but the presence of these enzymes appears to be a good index to susceptibility and this test could be a general guide to preventive medicine."

Dr Gilbert Omenn, who was a deputy science adviser to former US president Mr Jimmy Carter and now teaches medicine at The University of Washington School of Public Health, said doctors had known for years that some people seemed more susceptible to cancer than others. They had started tracking enzymes that detoxified cancerous agents only recently.

United Press International

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2 For each article, briefly describe the findings of the scientists.

3 What factors might affect the future influence of these discoveries?

4 Discuss your ideas with your partner.

5 Compare the two discoveries:
   (a) How useful are they?
   (b) What are the relative benefits and dangers?
   (c) What is their possible influence on society?

ACTIVITY 23
What can you find out about . . . ?

1 Find out what you can about the following people. What were their main scientific discoveries?
   (a) Karl Landsteiner
   (b) Alexander Fleming
   (c) Vladimir Zworykin
   (d) Susan Cory

2 How did their discoveries influence the world?

ACTIVITY 24
Why were these developments important?

Work in groups of three or four.

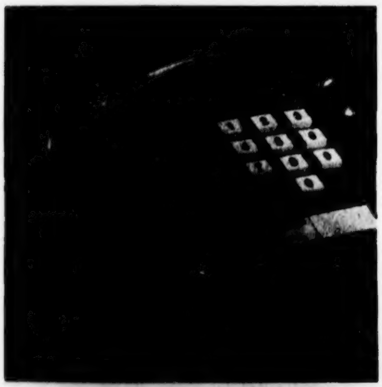
Steps to Take:

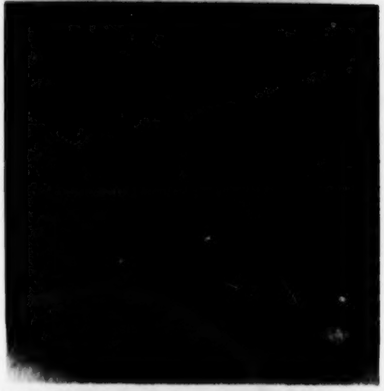
1 Each person in the group should write down as many applications of scientific discoveries that they can think of. (Try not to include any of those mentioned in the last activity.)

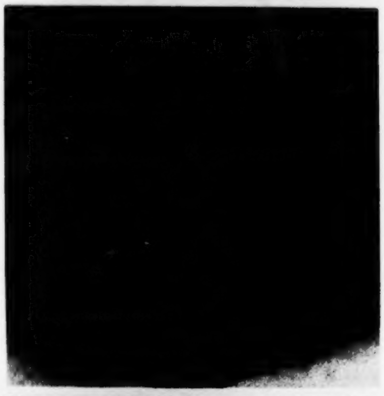
2 Pool your ideas so that you increase your list.

3 In a second column write down what the effects of these applications have been. (You may need to do some research on this.)

4 Discuss which things you consider have been the most important and why this is so.







So you can see from your own work that the application of scientific discoveries have strongly influenced our lives. For example:

(a) computers can be used to do some jobs that used to be done by people

(b) improvements in medical science have saved many people who would have otherwise died.

SUMMARY

Science involves:

- **searching for information**
- **stating hypotheses**
- **designing experiments**
- **controlling variables**
- **using the senses to make observations**
- **accurately recording the results of these observations**
- **making conclusions**
- **influencing society through the discoveries made.**

WORDS

Make a list of all the new words you have found in this chapter. Check that you can spell each one and make sure that you know what each word means or refers to. Do this for each chapter.

This list will get you started.

scientist
record
investigate
equipment
conclusion
scissors
scale
temperature
clinical
measuring cylinder
liquid

observation
senses
experiment
method
control
average
unit
celsius
column
beaker
millilitres (mL)

science
result
aim
apparatus
variable
measurement
thermometer
mercury
conical flask
pipette
meniscus

REVISION QUESTIONS

1 You add 200 g of copper sulphate crystals to 100 mL of water.
What do you think will happen to:
- the crystals
- the volume of the water?

(a) Write down your two hypotheses.

(b) Explain how you will set out to test your hypotheses.

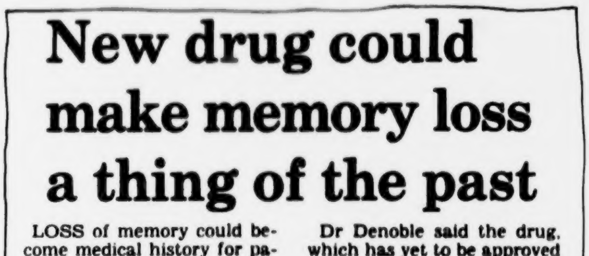
2 You find that slaters usually live under stones or pieces of wood. You set out to prove the hypothesis that slaters prefer a damp environment.

(a) Explain how you will test the hypothesis. Write a list of materials and equipment, and a method.

(b) Which variables have you controlled?

(c) Which variable(s) have you varied?

3 Read the following article and answer the questions.



New drug could make memory loss a thing of the past

LOSS of memory could become medical history for patients with brain damage thanks to a drug being developed in the United States.

Vinpocetine, produced by Ayerst Laboratories of Princeton, New Jersey, is said to be the most potent memory-restoring drug yet developed.

"It aids both remembering and learning," Dr Victor Denoble, of Ayerst, said. "Rats tested with the drug were able to learn a series of tasks 40 per cent faster than untreated rats. Moreover, treated rats were able to retain their memories even when subjected to memory-disrupting drugs or oxygen deprivation."

The effect of Vinpocetine is not a transient increase in alertness, which might be induced by a generalised stimulant such as caffeine. It speeds up blood flow to the brain, and appears to help the brain make better use of glucose and to jolt damaged parts of the brain back into action.

Dr Denoble said the drug, which has yet to be approved by the US Food and Drug Administration, was not intended for use by "normal" people who simply wanted to improve their memories.

"It will be used solely on those with impaired memories," he said. "Clinical trials will begin soon in the United States on victims of multi-infarct dementia, a disease which stunts blood flow to the brain and results in memory loss."

Quality

Dr Denoble said the results of trials in Germany, Italy and Japan were good. Patients were discharged earlier than expected and were rated by doctors and relatives as having better memory and an improved quality of life.

Vinpocetine is already on sale in Japan. If the drug is approved in the US, it could be on sale within three years, Dr Denoble said.

The Sunday Times

(a) What is the name of the new drug mentioned in the article?

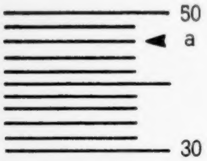
(b) What exactly is the drug supposed to do?

(c) How did scientists find out the effect of the drug?

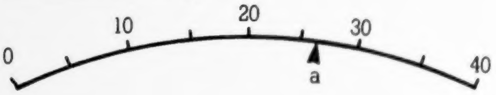
(d) How might this scientific discovery help some people?

4 Record your reading for each of the following scales.

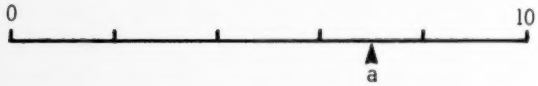
(a)



(b)



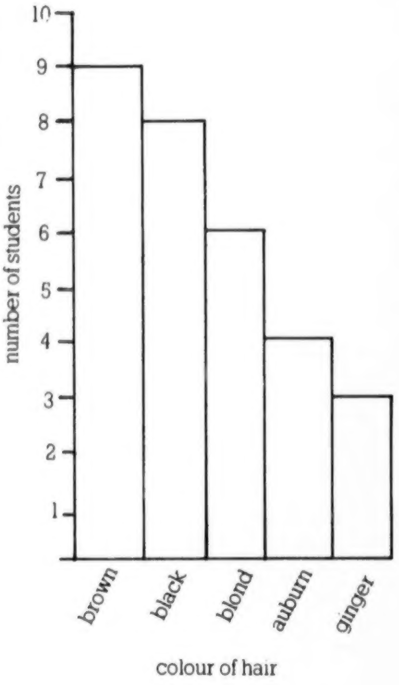
(c)



5 The graph on the right shows the number of students in a class with different coloured hair. Use the information to answer the questions below.

(a) What is the most common hair colour in the class?

(b) How many students have ginger hair?



6 Work out the averages of each of the following readings:

(a) 10 mL, 12 mL, 11 mL

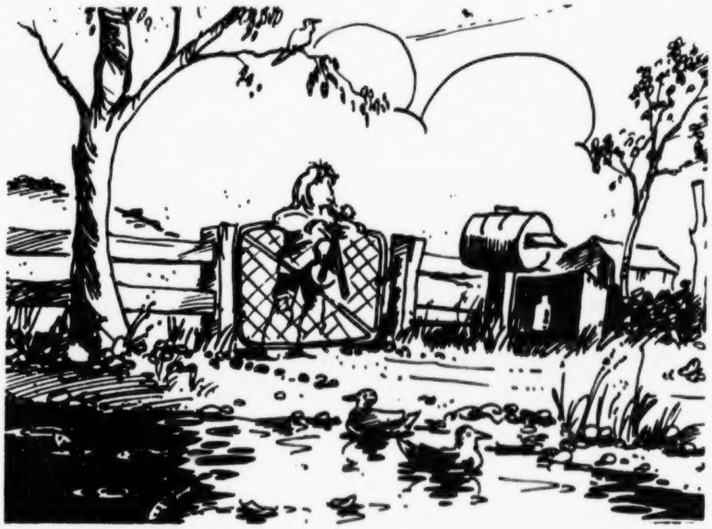
(b) 106 cm, 104 cm, 102 cm, 110 cm

(c) 4.6 litres, 2.4 litres and 3.6 litres

2 THE NATURE OF LIVING THINGS

In this chapter you will be looking at what makes something 'alive'. We will begin by investigating the word **biology**.

Biology, is the study of living things. The word biology comes from the Greek words: *bios* which means life, and *logos* which means a study.



At the end of this chapter you should be able to answer the following questions:

- What makes some things alive?
- What are the signs or characteristics of living things?
- What are the differences in the functions of animals and plants?

Reminder! If you come across new words, make a note of them and their meaning.

GETTING TO KNOW THE LIVING

When we observe the world around us, we see some things that we say are living and others which we say are non-living or dead. You may find it quite easy to make a list of living and non-living things. But it is difficult to explain what is meant by the word **living**. See how you go in the next activity.

ACTIVITY 1

Living or non-living

For this activity, work in groups of three or four.

Steps to Take:

1 First of all, working on your own, list the living and the non-living things in the drawing on the previous page. Use a table like the one below.

Living things	Non-living things
cat	table
tree	cricket ball

2 Compare your completed table with those of others in your group.

3 Explain what you think the words **living** and **non-living** mean.

4 Discuss your answers and ideas with others in your group.

You can find out more about living things on your own. The following activity is for you to do in your own time while you are working through this chapter.

ACTIVITY 2

What do you want to know about?

1 Write down any questions about living things you would like answered. For example:

- Why are leaves green?
- How do fish move?
- Why do we breathe?

Compare your questions with others in your group. Your discussions may lead you to think of new or more interesting questions. Remember that good questions are not necessarily complicated ones.

2 Select one question from Step 1 that you could investigate on your own.

3 Prepare a report on your investigation. You can work on this while you are working through this chapter. For example, you might want to investigate the question 'How do fish move?'. You could do this by visiting an aquarium and observing one or two types of fish as they swim. You should also visit the library and see if you can find any information that will help you answer your question.

We are able to describe what living things are. Living things are similar in a number of ways. For example, all living things need food. We call these similar features **characteristics**. A few of these characteristics may be found in some non-living things, for example, all living things can move in some way or another. Cars can move, but we know they are not living.

ACTIVITY 3

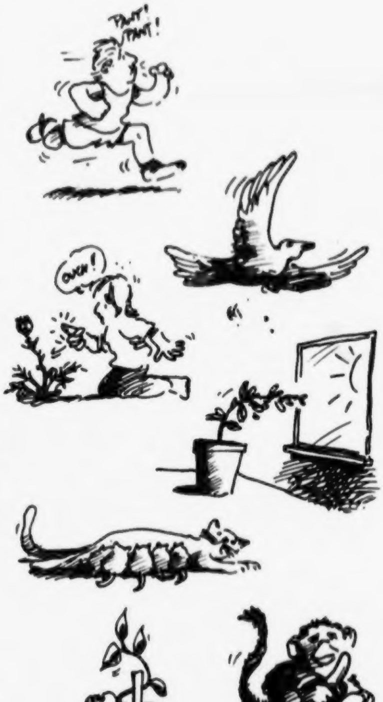
What are the characteristics of living things?

For this activity work in pairs.

Steps to Take:

1 Make a list of characteristics of living things. Use the drawings on this page to help you.

2 Check your list with the summary at the end of this chapter.


PANT! PANT!
OUCH!

You have now divided things up into two groups: living and non-living. You have also thought about some characteristics of living things.

We will now have a closer look at some of these characteristics in the following sections.

MOVEMENT

All living things are able to move. Most animals move about using legs, wings or fins. Some even move using rows of small hair-like structures (cilia) and others move by using muscles inside them. Plants often move, for example towards a light source, by growing in that direction. The roots of the plant grow down into the soil and the shoots and leaves grow up to reach the light.

EXPERIMENT 1

Why do plants move?

This experiment could be done as a demonstration.

Think about this question: 'Can a pea seedling move?'.

(This experiment will take approximately eight hours to complete.)

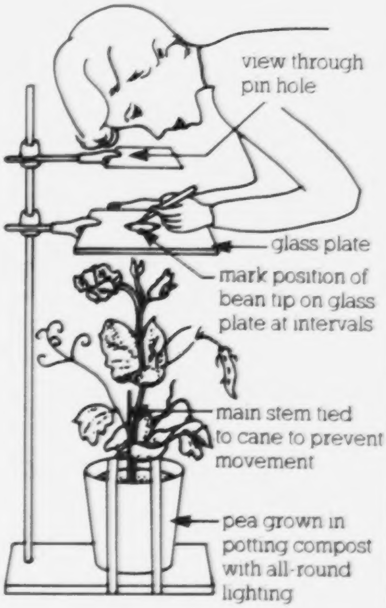
You Will Need:

- A pea seedling about 3 cm high.
- A square of glass or plastic about 10 cm × 10 cm
- A permanent texta
- A stand and clamp
- A cotton reel

Steps to Take:

1 Set the experiment up in the same way as shown in the diagram. The plant must have light falling on all sides.

2 With the texta put a mark on the plastic square directly above the seedling tip. Next to it, note the time.


view through pin hole
glass plate
mark position of bean tip on glass plate at intervals
main stem tied to cane to prevent movement
pea grown in potting compost with all-round lighting

3 Repeat Step 2 every two hours where possible.

4 After 24 hours, draw the pattern of movement in your notebook.

5 (a) What growth 'pattern' does the plant make?
  (b) What caused your seedling to move?
  (c) Can a plant move like an animal?

6 What advantages do you think an animal has in the way it can move? Discuss your ideas with others.

ACTIVITY 4

What are some other ways that plants move?

Steps to Take:

1 Use the library to find out about other plant movements. Write a short report on two examples of plant movement that interest you.

2 Using your previous experience and what you have read on plant movement, think up a question about the movement of a plant growing in your garden or a potted indoor plant. Carry out some simple experiments to find the answer to your question.

Now let's look at some movements in animals.

ACTIVITY 5

Do all animals move in the same way?

Work in pairs for this activity.

You Will Need:

- Any examples of animals (birds, fish, cats, dogs, yourself, snails, insects). You can observe them in the school grounds or in your garden.

Steps to Take:

1 Make up a table like the one below and make observations about each of the animals. (Remember to leave enough space between each.)
  (a) Describe how it moves.

(b) Describe what parts, or structures, you think it uses for movement.

(c) Number the animals in order from the slowest to the fastest.

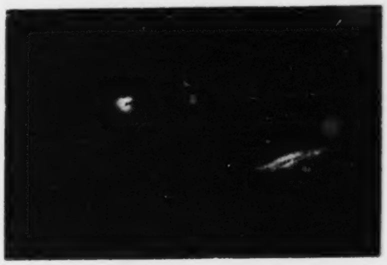
Name of animal	Description of movement	Structures for movement	Order from slowest to Fastest

2 Write a paragraph comparing the movement of two of the animals listed in your table.

Now let's look closely at how an earthworm moves.

ACTIVITY 6

How do earthworms move?



For this activity work in pairs.

You Will Need:

- A hand lens or stereo microscope
- An earthworm
- Brown paper and a pane of glass

Caution! Do not let the earthworm dry out.

Steps to Take:

1 Put the earthworm on a piece of brown paper.

2 Use your hand lens to observe the earthworm closely. Describe carefully what you see in your notebook. Put your ear to the paper. Record what you hear.

3 Put the earthworm on the pane of glass. Again record your observations.

4 Lift up the glass and use your hand lens to examine the underside of the earthworm.

5 Write down your ideas about how you think the earthworm moves.

6 Compare your ideas with those of your partner.

Now we need to compare movement in animals and plants.

ACTIVITY 7

What's the difference between the ways plants and animals move?

For this activity work in groups.

Steps to Take:

1 Discuss your ideas about how movement in animals and plants is the same and how it is different. Draw up a table and record your ideas in it.

2 If you need to check anything, carry out further observations.

3 Discuss your ideas with others in the group. Add any other ideas they may have to your table.

Plants move very slowly. For example, stems move in a spiral or they bend towards light. These movements depend on growth. If one side of a stem grows faster than another, the stem bends.

Movement in animals is relatively fast, even for earthworms. Animals, unlike plants, move from place to place. They use parts of their bodies to help them move.

FEEDING

All living things need food to get their energy for living. Many animals spend much of their time in search of food. They get their food by eating other living things. Some, including humans, also eat animal products – milk, butter, cheese – and plant products such as margarine, nuts and cereals.

Plants also feed but, unlike animals, they 'make' their own food. They get raw materials like mineral salts and water from the soil and carbon dioxide from the air around them and use the energy of sunlight to make food.

What is energy? We often talk about ourselves as 'having energy to do things', and about food 'giving us energy'. There are two kinds of energy: energy for moving, and chemical energy. Energy is also found in the form of light, sunlight, heat and nuclear energy.

ACTIVITY 8

What do we use energy for?

Work in groups of three or four for this activity.

Steps to Take:

1 Discuss your ideas with others in your group.

2 Write down your ideas about the answer to this question.

Now we need to find out where the energy comes from.

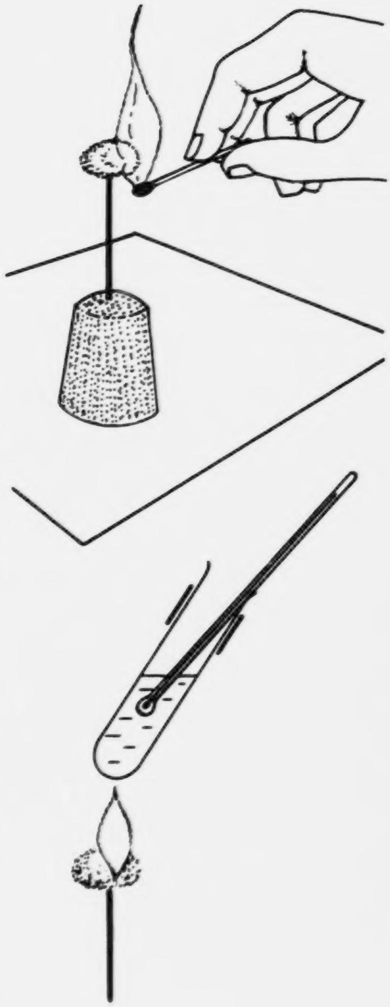
EXPERIMENT 2

Is there energy in food?

You Will Need:

- An unsalted cashew nut or a marshmallow

- A needle
- A small cork
- A heat-proof mat
- A Bunsen burner
- Matches



Steps to Take:

1 Set up the experiment as in the diagram.

Safety! Remember the dangers involved with fire.

2 Carefully light the nut or marshmallow with a match and record your observations.

3 (a) When the nut or marshmallow was burnt, was there energy given out? If so, what type of energy? How could you test out your idea?

(b) What happens to the nut or marshmallow?

(c) Would your body be able to cope with the amount of heat the nut or marshmellow produced in such a short time?

(d) How is the energy provided by food for our bodies different from the heat produced by burning food with a match. (Clue: check your reading for body temperature in Chapter 1.)

4 Compare your ideas with others.

Now we need to think about where our energy comes from.

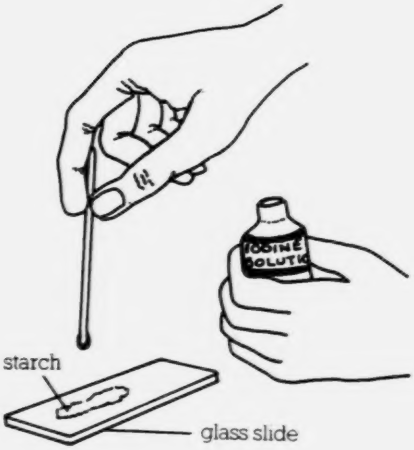
Our energy comes from different foods. The foods we eat contain various types of food substances known as **carbohydrates** (including **starch** and **sugars**), **proteins** and **fats**. These are the main energy sources.

Other substances found in smaller amounts in foods are called **mineral salts** and **vitamins**. These substances are not the main energy sources but many of them need to be present before energy is released.

In the next activity we will learn how to test food for starch. Energy is commonly stored as starch in our food.

EXPERIMENT 3

How can you test for starch?



You Will Need:

- Iodine solution
- Two glass slides
- Powdered starch
- A glass rod
- A spatula
- Sugar

Steps to Take:

1 Add a little powdered starch to a glass slide.

2 Write down the colour of the starch and also the colour of the iodine solution.

3 Add one drop of iodine solution to the starch.

4 Record any change in colour.

5 Compare the change in colour you have just observed with what happens when you add iodine solution to sugar.

6 Write a short description of this test for starch in your notebook.

We can use this test for starch in the next activity. Think about the question – Where is starch found?

EXPERIMENT 4

Is there starch in a green leaf?

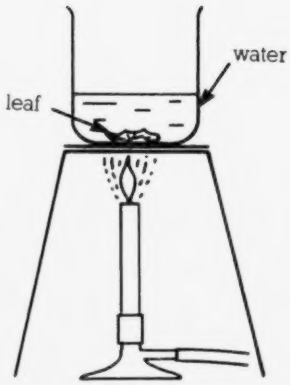
If you are going to test for the presence of starch in a leaf it is important to first remove the green pigment called **chlorophyll**.

Your teacher may wish to do this experiment as a demonstration.

You Will Need:

- Some geranium leaves (or those from a similar plant) that have previously been in the light

- An evaporating dish or test-tube
- A small beaker
- About 10 mL of methylated spirits
- A Bunsen burner, tripod and gauze or electric hotplate
- A pair of forceps or tweezers
- A 25 mL measuring cylinder
- A white tile or sheet of white paper
- A dropper
- Iodine solution
- A heat-proof mat



Steps to Take:

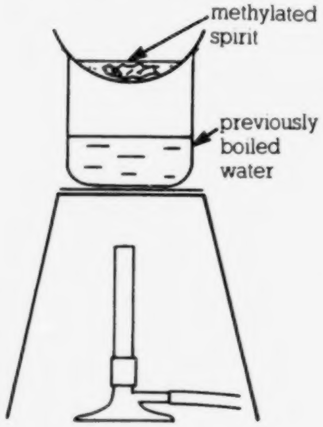
1 Boil some water in a beaker.

2 Boil a leaf in the water until it becomes limp. Turn off the Bunsen burner.

3 Pour about 10 mL of methylated spirits into an evaporating dish.

4 Lift the leaf out of the water, drain it and then add it to the methylated spirits.

5 Warm the methylated spirits over the hot water.



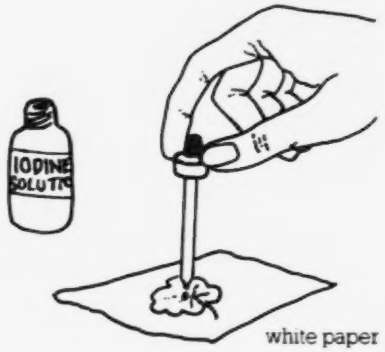
Safety! Do not use methylated spirits near a flame. Add a little cold water to it if it does catch fire.

6 Remove the leaf from the methylated spirits when most of the chlorophyll has been removed and rinse it in the hot water.

7 Lay out the leaf on a white tile or sheet of paper.

8 Add one or two drops of iodine solution to the leaf.

9 Record your observations in your notebook. Explain what these observations mean.



The next activity will help us to find out how plants usually feed.

EXPERIMENT 5

Is light necessary for starch formation in leaves?

Work in pairs. Decide how you are going to test the question and write a report on your findings.

What else is necessary for plant development other than light?

ACTIVITY 9

How do plants feed in other ways?

Steps to Take:

1 Use the library to find out about the unusual ways some plants and animals feed. (Clue – look up words like *parasite* or *saprophyte* or plants such as mushrooms, pitcher plants or 'Venus Fly Traps.)

2 Write a report for a newspaper about one of the plants you have read about. (Remember, people only read newspaper articles if they are *interesting*!)
You should include drawings where possible.

ACTIVITY 10

Comparing feeding in plants and animals?

Write a summary comparing the ways that most plants and animals get their food.

We have seen that food contains energy. We did this by allowing it to burn. However, we know that energy is released from our food without burning because there is no fire inside us. Starch is a common food substance produced in green leaves using energy from the sun.

Plants and animals need food so that they can produce energy for their various activities. In the next section we will learn about **respiration**.

RESPIRATION

Respiration is a process in which energy is produced.

We have seen that energy comes from food. The air is made up mainly of nitrogen and oxygen. The oxygen is important to us. When oxygen from the air combines with food in the cells, energy is released, together with carbon dioxide and water.

oxygen + food → ENERGY + carbon dioxide + water

In many animals oxygen has to be transported from organs like our lungs or the gills of fish, via the blood, to the cells. This is where energy release occurs.

EXPERIMENT 6

How do we know plants and animals respire?

When carbon dioxide is released we can assume respiration is occurring.

Work in pairs for this activity.

You Will Need:

- Three vials with caps
- Distilled water
- 0.04% bromothymol blue solution (used as a test for carbon dioxide production)
- Three small pieces of clean wire
- Gauze to fit in the vials
- A few slaters and some germinating peas

Steps to Take:

1 Try not to breathe over the equipment whilst doing this activity. (Why do you think this is important?)

Rinse the vials and wire gauze in the following solutions, in this sequence:

(a) water

(b) distilled water

(c) bromothymol blue solution.

2 Place about 2 cm of bromothymol blue solution in each vial. Place three slaters in one vial, the germinating peas in the second and nothing in the third. Place the caps on the vials.

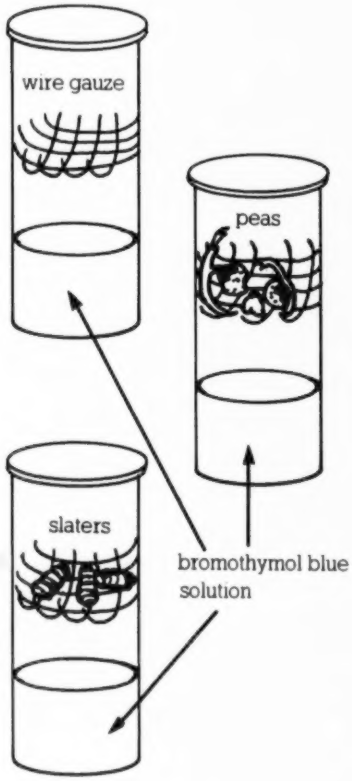
3 Put the vials in the dark.

4 After 20 minutes, shake the vials gently. Record what you observe.

5 (a) Did the bromothymol blue solution change colour? Which gas caused this change?

(b) Why did you have a vial with neither plant nor animal?

(c) Which respired more slowly, the plants or animals?



Many of the foods we eat are plants. In the next activity you can find out if some of them are alive or not.

EXPERIMENT 7

Are the foods we buy still living?

You Will Need:

- Three vials with caps
- Distilled water
- 0.04% bromothymol blue solution
- Three small pieces of clean wire
- Gauze to fit in the vials
- Examples of different foods, e.g. dried fruit, potato, glacé cherries, cheese.

Steps to Take:

Use the same procedure as you followed in the last activity to find out if the foods are living. Write a short report on your findings.

ACTIVITY 11

Does our breathing vary?

Steps to Take:

1 What happens to our breathing during sleep and strenuous exercise? Is our rate of breathing related to our energy needs?

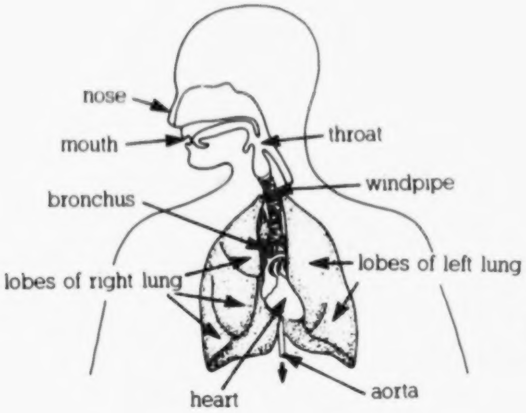
Write down your ideas and then discuss them with the rest of the class.

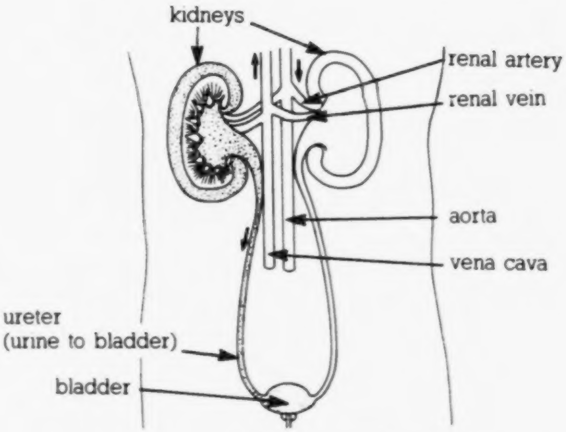
2 Work out how you could test one of your ideas. You could use step-ups as you did in Experiment 6 in the first chapter. (Check the safety note for this experiment.)

3 Write a report on your findings.

Respiration is the release of energy by living things. You know that food and oxygen are required for the release of energy. This means that animals need to eat and breathe for respiration to take place.

EXCRETION


nose
mouth
throat
windpipe
bronchus
lobes of right lung
lobes of left lung
heart
aorta


kidneys
renal artery
renal vein
aorta
vena cava
ureter
(urine to bladder)
bladder

The kidneys are the main excretory organs in humans. The lungs excrete carbon dioxide.

Excretion is the name given to the removal to **waste products**.

ACTIVITY 12

What is waste?

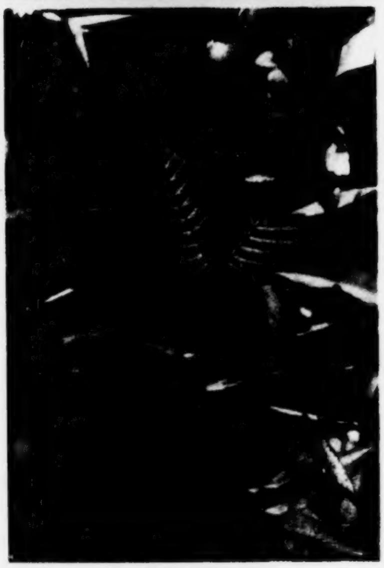
Steps to Take:

1. List all the waste products we produce.
2. Write down what you think our waste products result from.
   Discuss your ideas with a partner.
3. Which parts of the body are involved with producing waste?
4. Why is it important to get rid of waste products?
5. What are the waste products in plants and what happens to them? Do some research in the library to help you.
6. Do plants produce fewer waste products than animals? Why? Discuss your ideas.
7. Some non-living things produce waste products. What is the waste produced by a car or truck? From what part of the vehicle is it removed? How are people trying to reduce this waste? How does this waste affect living things?

We have to get rid of the waste products from respiration and food breakdown. This process is called excretion.

Note The solid food material that remains after breakdown is get rid of in the form of faeces. The faeces do *not* contain the main waste products and are not referred to as excreta.

RESPONDING TO STIMULI



The mimosa plant before and after being touched. Why do the leaves collapse when touched?

All living things can respond to changes in their environment.

How do you respond when you accidently touch a hot iron? Our **sense** organs tell us what is happening.

Light is very important to some animals, for example, woodlice move away from it and moths move towards it. Although plants do not have the same sense organs as animals, they are still able to respond. A plant may bend towards the light and some plants curl up when touched or when it gets dark. The mimosa plant's leaves collapse when touched.

We have **reflex actions** which protect us. A reflex action is something that happens without your control. You control your hands to catch a ball that is thrown to you but you don't have any control over the size of the pupils in your eyes.

EXPERIMENT 8

How good are your reflex actions?

For this activity work in pairs.

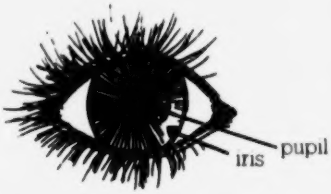
You Will Need:

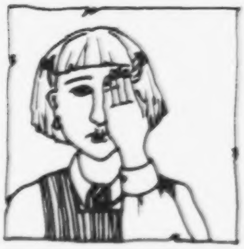
- A pencil torch or other light source
- A hand mirror

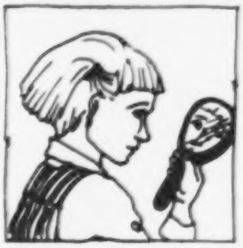
Steps to Take:

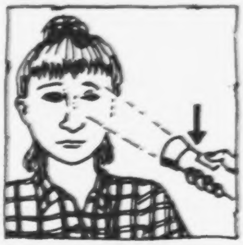
1 Predict what you think will happen to the pupil in your eye when a torch is shone into it?

2 Look into your eye and find the **iris** (use the diagram). The black hole at the centre of the iris is called the **pupil**. It is controlled by the muscles of the iris.









3 Look at your pupils in the mirror. Now cover one eye with one of your hands and wait about thirty seconds. Your partner can watch the time.

4 Take your hand away, and look at the eye in the mirror.

5 Describe in your notebook how your pupil changes.

6 See if your partner's eye reacts the same way.

7 Hold your hand over your eye for another 30 seconds.

8 When you take your hand away, your partner will shine a torch in your eye, and watch your pupil.

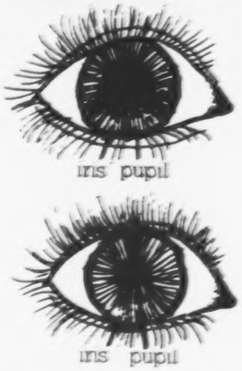
Safety! Shine the torch for a very short time only — less than one second — otherwise you could damage the eye.

(a) How did the pupil change this time?

(b) How does the effect of bright light on the pupils differ from the effect of covering your eye with your hand?

9 Write down why you think the pupil responds to bright light in this way.

10 Explain why you think sunglasses protect the eyes.



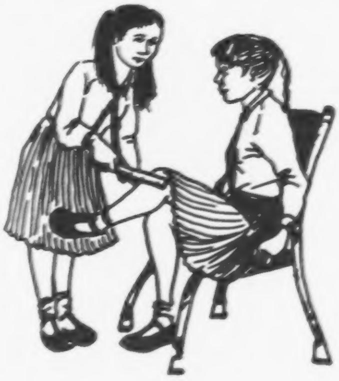
How does light affect pupil size?

Another well-known reflex is the knee jerk reflex. The reflex occurs when the knee is tapped just below the knee cap.

ACTIVITY 13

The knee jerk reflex

Steps to Take:



1 Try out the knee jerk reflex on your partner.

Safety! Don't hit too hard!

2 Write down your ideas about how you think the reflex works.

3 Compare your ideas with those of others.

4 How do you think this is different from the way the mimosa plant reacts to touch?

Write down all the ideas from your group. After you have discussed them, underline the most likely ideas. Use the library or other resources to check whether you are correct.

5 Write down examples of other reflexes.

6 Describe why doctors test your reflexes.

7 Why do we have reflex actions? Why are they important?

Living things respond to light and other stimuli. Reflex actions such as the knee jerk illustrate how quickly we can respond to stimuli. When we look at plants in Chapter 6, we will see that they respond more slowly, for example by growing towards a light source.

REPRODUCTION

All living things die at some stage. They must be replaced by new living things. Living things can produce others like themselves. When they do this we say they **reproduce**. Most animals are either male or female and can mate and reproduce young.

Plants also have male and female parts. In various ways the male cells* are transferred to female cells and new plants are produced.

Some very small plants and animals can reproduce by splitting in two.

Plants also reproduce by parts of a plant breaking away from the parent plant. This process is called **budding**.

EXPERIMENT 9

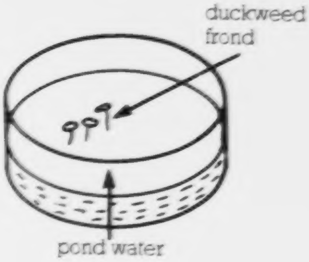
What is budding?

You Will Need:

- Some duckweed
- Pond water or water culture solution

* **Cells** are discussed in detail in Chapter 4.

- A hand lens or stereo microscope
- A Petri dish (10 cm diameter) or similar dish



Steps to Take:

1 Put two or three duckweed fronds in some pond water in the dish.

2 Draw up a table and record the number of fronds each day for two or more weeks. Remember to top up the pond water.

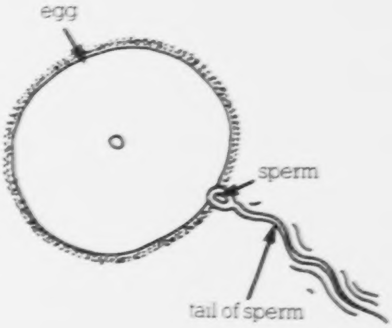
3 Use the hand lens to look closely at the fronds. Draw one to show how the new fronds are being produced. Remember to make the drawing big and clear.

The last activity was an example of **asexual reproduction**. In this case, a parent frond gave rise to similar fronds by **budding**.

Asexual reproduction results in the development of offspring from only one 'parent'. Where reproduction occurs after mating between a male and a female it is said to be **sexual reproduction**. Sexual reproduction results in the development of offspring from two different individuals.

Some animals and plants reproduce by sexual reproduction. In animals, the male cells are called the **sperm** cells. These have only a small amount of cell material and whip-like tails by which they can swim to the egg. The female cell, or egg, is much larger and has much more cell material on which it can feed.

The reproductive organs ensure that the male and female cells meet. When the cells meet, the process is called **fertilisation**. The fertilised egg grows to become a new being or organism.



ACTIVITY 14

Sexual or asexual – what's the difference?

Steps to Take:

1 Discuss in your group, and then as a class, what you consider are the similarities and differences between sexual and asexual reproduction. What are the benefits of both?

2 Write a short report on your findings. List any unanswered questions.

We have seen that living things reproduce themselves either by sexual or asexual means.

GROWTH

Animals grow until they reach adult size. As we grow, some parts of our body become larger and much heavier than others. That is, some parts grow much faster than others. Every year most children grow in height until they reach an age where they are fully grown. Some animals pass through different growth stages, for example, the moth has four stages:

(a) egg
(b) larva
(c) pupa
(d) adult stages.

ACTIVITY 15

Where do moths come from?

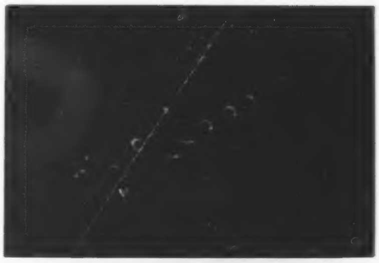
Steps to Take:

1 Look at these photographs. They show the different stages of growth of the Emperor Gum Moth.

2 Find out more about each stage of the moth's life cycle. Consider the relative sizes of the animal at each of the stages, what each stage looks like, and what happens to the animal to allow it to progress to the next stage.

3 How could you compare the growth of a dog and the growth of the moth. Do dogs go through different stages of growth?

Now let's look at growth in the frog. *You will have started another chapter before you complete the next activity.* This is because frogs' eggs take time to grow.



ACTIVITY 16

Looking at frog spawn

You Will Need:

To collect some frogs' eggs from a local pond or dam. Place them in a tank or large bucket and observe them regularly. You will need to look at them over a number of weeks. Each time you look at them, draw what you see and make notes. Do not forget to record dates.

Steps to Take:

1 Make observations over a period of about ten weeks.

2 When you have completed your observations, answer these questions:

(a) Why can the tadpole live in water? How does it breathe?

(b) Why does the frog produce so many more eggs than a chicken?

(c) In what ways would you compare the life cycle of a frog with our own life cycle?

Now it is time to look at growth in plants.

EXPERIMENT 10

How do plants grow?

You Will Need:

- A potted pea seedling, a few centimetres high
- A texta

Steps to Take:

1 Using your texta, mark the seedling carefully in half-centimetre intervals from the tip of the plant to its base.

2 Leave the plant for a couple of weeks (or longer if possible) and then check to see if the intervals between the markings have changed.

3 Make a record of your findings.

4 (a) Were there any growth spurts that you could detect?
  (b) Did the plant appear to change in form during its growth?
  (c) Did any parts of the plant grow more than others?
  (d) Do plants ever stop growing before they die?

Now let us compare growth in animals and plants.

ACTIVITY 17

Do animals and plants grow differently?

Steps to Take:

1 Choose a particular plant in your garden and think about how it grows. Is it different from the way you grow?
Hint: Think about which part(s) of the organism grow(s). Do animals ever stop growing?

2 Select an animal or plant and work out a way you could check the differences.

3 Write a brief report on your findings.

ACTIVITY 18

So what does it all mean?

Steps to Take:

1 Look back over your work on this chapter.

2 Write down a list of questions you would like to find out about for each of the various functions (movement, feeding, respiration, excretion, etc.) in animals and plants.

3 Write a paragraph comparing each function in animals and plants.

4 Compare your ideas with others.

You have looked at some different patterns of growth as they occur in butterflies, tadpoles and plants. In Chapter 1 you also compared how tall people in your class had grown.

SUMMARY

A COMPARISON BETWEEN THE FUNCTIONS OF ANIMALS AND PLANTS

	Plants	Animals
Movement	Movement is very slow. It is the result of growth. Plants do not move from place to place but parts of the plant may bend, e.g. the stem towards light, and flowers open and close.	Movement can be relatively fast. Can move from place to place. (This is called locomotion.)
Feeding	Green plants make their own food using sunlight. In the presence of chlorophyll, sunlight uses carbon dioxide and water and changes them into chemical food.	Feed on animals, plants or ready-made foods.
Respiration	Respiration is the process in which energy is released by living things. It is the same process in animals and plants. When oxygen from the air combines with food, energy is released.	
Excretion	This is the removal of waste products in animals and plants. If these waste products remain in large amounts they can poison the animal or plant.	
	Generally less need for excretion and fewer waste products. (Later we will see that plants may produce excess oxygen from food manufacture. By definition this is a waste product.) Some waste products are stored as solids in a non-poisonous form, e.g. crystals.	Greater need for excretion as large amounts of unwanted materials are produced from the breakdown of food. Animals have special organs for excretion. Our bodies have kidneys, lungs and skin

	In both plants and animals, carbon dioxide is released as a gas from the process of respiration.	
Responding to stimuli	Respond relatively slowly	A fast response because of the presence of a nervous system. Messages can pass along the system very quickly.
Reproduction	Sexual reproduction can occur in animals and plants when there is a union of a male cell and a female cell. Asexual reproduction occurs in such ways as simple division or budding.	
Growth	The main growth region is near the tip. Plants continue growing until they die.	Although different parts of our bodies grow at slightly different rates our bodies grow as a whole, i.e. we do not grow just from the top of our heads. This is typical of all animals. Once an animal reaches a certain size, growth stops.

REVISION QUESTIONS

1 You are given an object in a specimen jar. Nobody is sure whether it is living or dead. Write down the ways you could use to find out whether it is living or not.

2 Compare the movements of a housefly with those of seaweed or fern.

3 Why do animals and plants need food?

4 Compare the way a plant obtains its food with the way an animal does.

5 Why do we need more food in colder climates?

6 Imagine you are testing for the presence of starch in two green leaves from two different plants, A and B. When you apply the iodine solution to a leaf from plant A, it turns blue-black. The leaf from plant B remains the brown colour of the iodine solution. How might you account for this observation? How could you check out your idea?

7 What is the difference between sexual and asexual reproduction?

8 Which answer is correct?

The purpose of respiration is to produce:

(a) carbon dioxide
(b) food
(c) water vapour
(d) energy
(e) oxygen.

9 Give an example of a reflex action.

10 Imagine that you wanted to test whether or not germinating beans were respiring.

(a) Describe the equipment you would need.
(b) Describe the method you would use.
(c) Which variable(s) will you need to control?
(d) Which variable(s) will you vary?

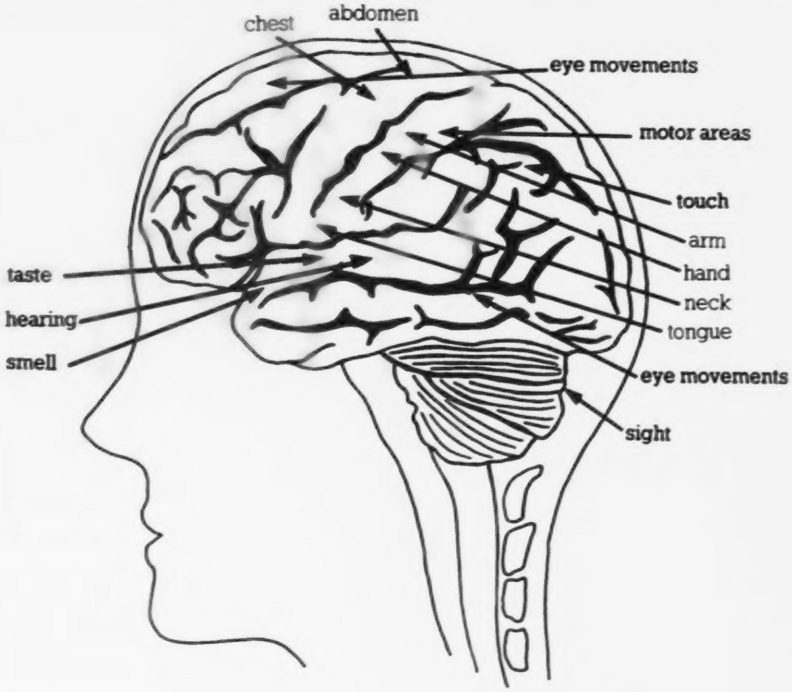
11 (a) What is meant by *excretion*?
(b) What are our main excretory organs?

12 The amount of oxygen used by 10 slaters and 10 spiders kept in the same conditions was measured at two different temperatures, 10°C and 25°C, for one hour. The results are recorded on the following table.

	Volume of oxygen used in one hour	
	10°C	25°C
10 slaters	1cm^3	10cm^3
10 spiders	4cm^3	35cm^3

(a) Why is there a difference between the amounts of oxygen the spiders and the slaters used? Write down your ideas.
(b) Why is oxygen used by the slaters and spiders?
(c) Write down your ideas about why the different temperatures affected the amount of oxygen used.

3 USING OUR SENSES


chest
abdomen
eye movements
motor areas
touch
arm
hand
neck
tongue
eye movements
sight
taste
hearing
smell

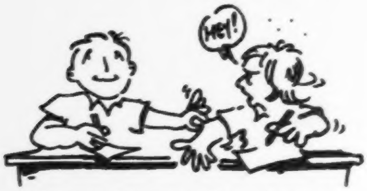
How do you become aware of the world around you? As you get older you can recognise different people, places, sounds, tastes and feelings. You probably take little notice of how you recognise different things because you are so used to doing it.

This chapter will help you learn more about your senses. When you have completed all the activities you should be able to answer the following questions:

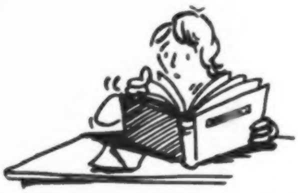
- What are the five senses?
- How are the senses co-ordinated?
- How do the senses help us explore our environment?
- How reliable are your senses?
- How do the senses help us communicate?
- How do the senses influence our lives?

YOU AND YOUR SENSES

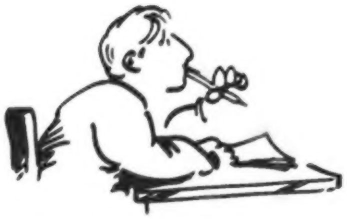
Can you think of your five main senses? Use the pictures and sentences to help you.



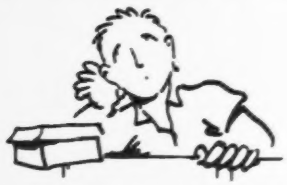
"Peter! Stop pinching Maria."



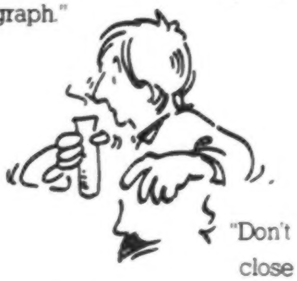
"Turn to page 20 and read the first paragraph."



"Stop chewing on your pen."



"If you listen very carefully, you should hear it."



"Don't put the test tube close to your nose."

The pictures show the sense organs, but your five senses are:

1 touch
2 sight
3 hearing
4 taste
5 smell.

You probably realise now what your senses do, but try the next activity to make sure.

ACTIVITY 1

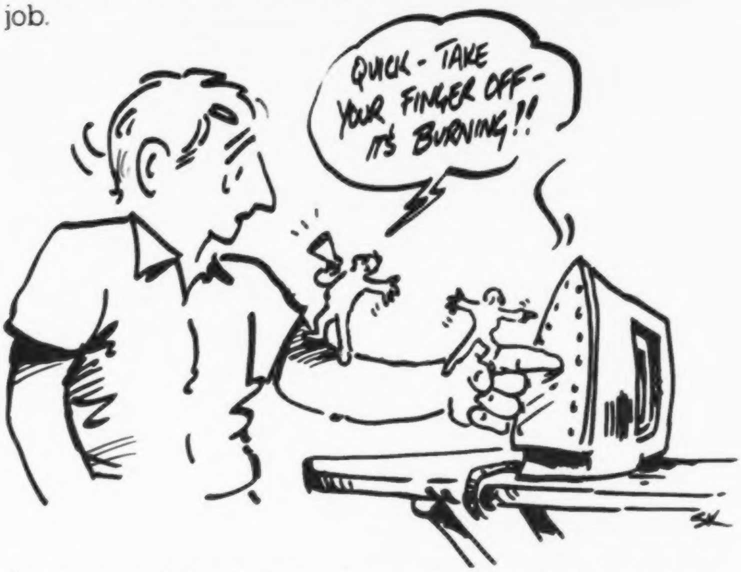
Checking out the senses

Steps to Take:

1 Write down all things you have done so far today that have involved each of your senses. Hurry — you only have two minutes!

Are you surprised at how many times you have used your senses of sight, smell, hearing, touch and taste in a day, without stopping to think about it?

Now that you have looked at what your senses do, think about how they do it. How do you know you are touching something cold and hard, or hearing a loud noise, or smelling a rose? Well, it certainly isn't a lot of little people running around inside your body telling you. It is, however, something that does the same sort of job.


QUICK - TAKE YOUR FINGER OFF - IT'S BURNING!!
SK

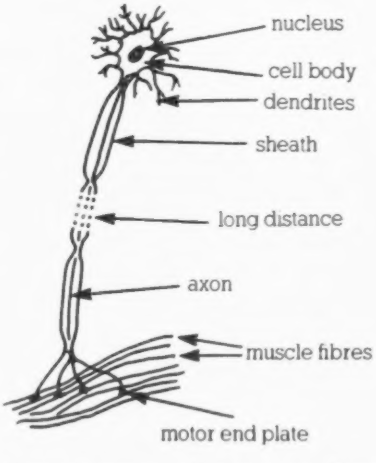
In everyone's body there is a very important part that controls all the body's activities, including the senses. This is the **brain**.

Now think carefully about this controller of our bodies. We all know where our brains are located. Some of our sense organs are a long way away from it, though. Can you see a problem?

If you put your big toe in ice cold water, you soon pull it out. Yet your big toe is a long way from your brain. How does the brain find out so quickly that the water is too cold?

The senses are linked to the brain via **nerves**. Nerves are long threadlike cells. There are millions of nerves in the body. They form many pathways to and from the brain.

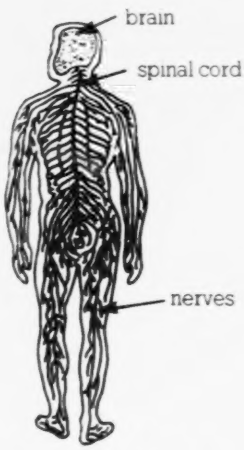
The brain, nerves and spinal cord make up the 'controller' of the body. Together they are called the **nervous system**. The brain co-ordinates the nervous system. It is this large network of nerves that allows you to react to certain situations.



A single nerve cell. The nerve fibre may be several metres in length.

You will have noticed from the diagrams that the brain is made up of different parts. This is because of the variety of jobs that it does.

Turn to the picture at the beginning of this chapter. Different parts of the brain receive different messages and react accordingly.



Notice how the network of nerves spreads throughout the body. Many travel through the hollow bones in the spine to get to the brain.

LONG-DISTANCE SENSES

Sight and **hearing** are long-distance senses. They bring information to us about things that may be far away. You can hear sirens though they may be some distance away, and the stars you see are millions of kilometres away.

Sight

What do peoples' eyes tell you about them?

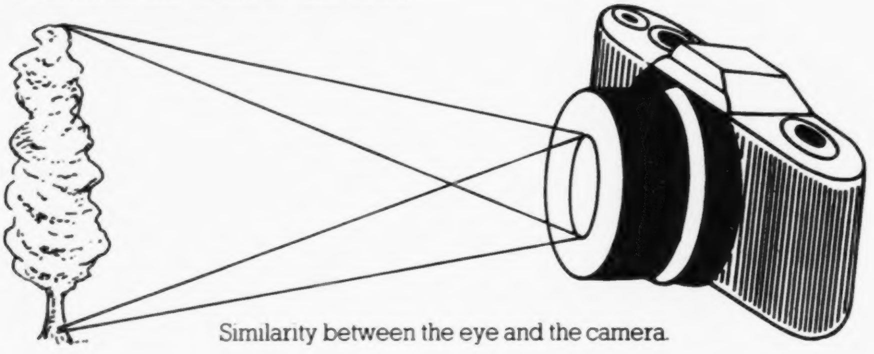
We use our eyes to get most of the information about our surroundings. In science you are often asked to observe something carefully. This can be done using your eyes. You read, watch television, play sport, in fact, almost everything you do involves your eyes.

Your eyes are very important to you. It is therefore quite important to understand how they work.

The human eye works very much like a camera.

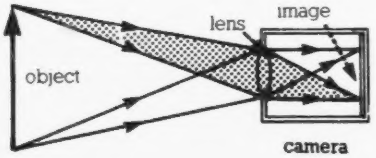
When you look at something, the object forms an image on a screen at the back of the eye. This screen is a layer of cells, which are sensitive to light. It is called the **retina**. The retina sends messages to your brain through a nerve called the **optic nerve**. The brain receives the images and you see the object.

A camera works like this too. It forms an image on a screen at the back of the lens.

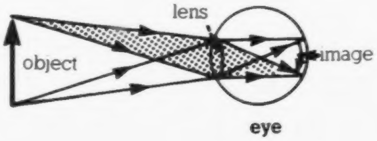


Similarity between the eye and the camera.

A camera obviously doesn't have a brain to see the objects. Chemical processes are used to produce the image on paper.



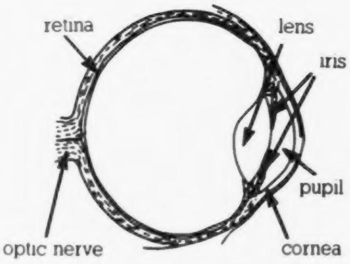
How a camera forms an image.



How the eye forms an image.

There are a number of parts to the eye. All parts help to present a clear and specific picture to you.

The **cornea** is on the outside of the eye. It is clear and allows light into the eye. In the middle of the eye is the **pupil**. This is the black circle in the centre of the coloured part of your eye. Though the pupil may look

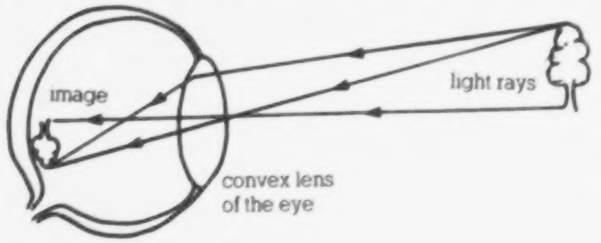


Side view of human eye.

solid, it is really just a gap that lets more light in.

The pupil cannot get bigger on its own. It needs help. The **iris** does this. It is the coloured part of the eye. It controls the amount of light entering the eye by muscular movement.

Behind the iris is the part of the eye that helps to focus images. It is called the **lens**. The lens is clear and flexible. The lens in your eye is a **convex** lens. A convex lens is one which is thicker at the centre than at the edges. It bends light as it passes through it. This bending of light forms an image at the back of the eye.



How does the eye form an image?

ACTIVITY 2

How does the lens form an image?

You Will Need:

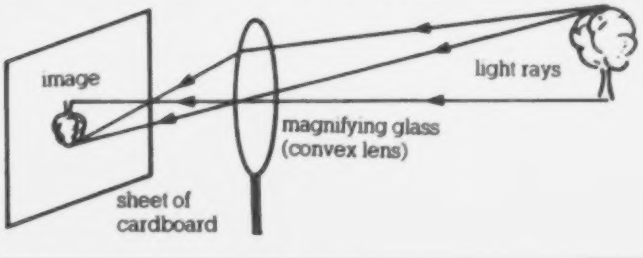
- A magnifying glass
- A sheet of stiff white cardboard

Steps to Take:

1 Stand with your back to the window. Hold the piece of cardboard up to face the window.

2 Hold the magnifying glass up between the card and the window, with a clearly visible, well-lit object outside. A tree might be good.

3 Now move the magnifying glass away from, or towards the cardboard until a 'picture', or image of the window frame, or tree, appears on the card.



Using a magnifying glass to form an image

4 Write down what you observe about the image.

This is exactly how your eye forms an image. Most people get nice clear images of objects but some people have faulty lenses and the images appear blurry. Wearing glasses or contact lenses easily fixes that problem. The glasses and contact lenses are just extra lenses to help the person's faulty ones.

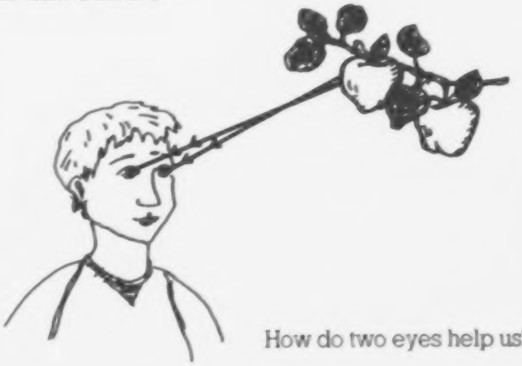
ACTIVITY 3

Why do some people wear glasses?

There are two very common eye complaints that can be fixed with glasses. Find out:

- what they are called; and
- how glasses help these faulty lenses

Discuss your findings with a partner.



How do two eyes help us?

Binocular vision

You have looked at the eye and its parts. You have also seen how the eye can form images of objects. Now let's look at how we use two eyes.

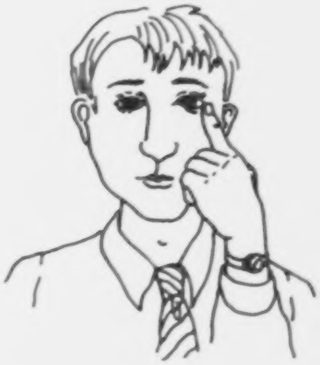
Most people have two eyes that are identical, so you might ask why we need two at all. But using two eyes to see is quite different from using one. When you look at an object with both eyes you are seeing it in three dimensions. This means that you can judge distance accurately. Being able to see in this way is called having **binocular vision**.

ACTIVITY 4

Is there a difference?

This is a short activity to show that two images can be formed by the eyes, even though you are looking at one object.

Steps to Take:



1 Focus on an object in the room or on a line of writing on this page.

2 Place a finger at the corner of your bottom eye lid.

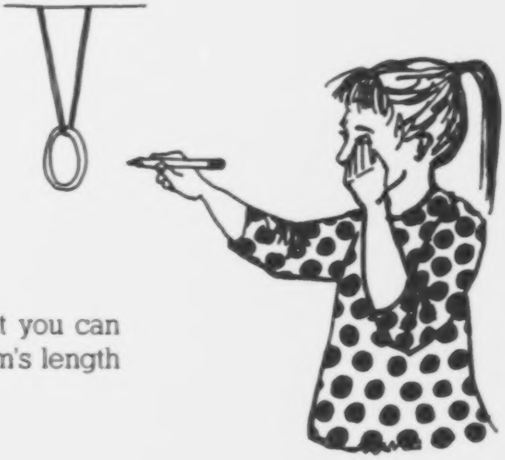
3 *Gently* apply pressure. You should be able to see two images, even though you were looking at only one object.

ACTIVITY 5

How well can you judge with one eye?

Work in groups for this activity.

You Will Need:



- A brass ring on string
- A pen

Steps to Take:

1 Get your partner to hold the string so that you can only see the edge of the ring, about an arm's length away.

2 Cover one eye.

3 Try to pass a pencil through the ring.

It isn't quite as easy to judge distances with only one eye, is it?

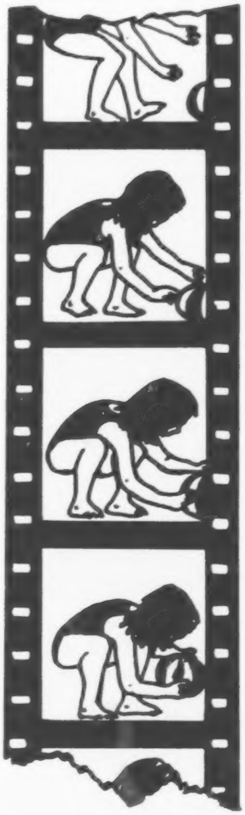
Persistence of vision

When an object is taken away from view, you don't see it any more. Your brain and retina do though. The nerves in the brain and retina keep an impression of the image for about a tenth of a second after the object is removed. This is known as **persistence of vision**.

Films and television use persistence of vision to make you see a continuous movement on the screen. Really you are seeing a series of slightly different images called **frames**. When you view these frames, because of persistence of vision, they merge as a continuous film.

You might have seen an old home movie of your family or friends, and noticed that it is quite jerky. This is because home movies only use 18 frames per second. Film and television cameras use 24 frames per second. Videotapes show 50 frames per second. That is the reason why videotapes look so smooth when they run.

So really your eyes are being tricked into seeing continuous action. There are quite a few ways to fool your eyes.



ACTIVITY 6

Is it caged?

This is an activity to demonstrate persistence of vision.

You Will Need:

- A piece of cardboard (about 10 cm × 7 cm)
- String
- Scissors

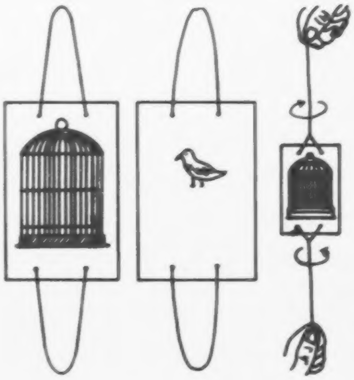
Steps to Take:

1 Draw a birdcage on one side of the cardboard (about 8 cm × 5 cm) and the bird on the other side.

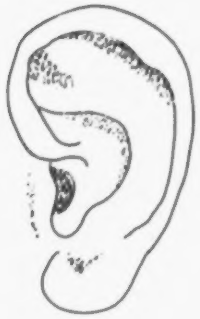
2 Fasten loops of string through holes in the cardboard, as shown in the diagram. Twist the strings, then pull them taut. The card will spin around.

3 Describe what you see. Write down why you think you see what you do.

4 Discuss your ideas with a partner.



Hearing



To understand how your ears work, you must first understand how sounds are made. You hear so many different sounds in a day – loud, soft, dull or piercing sounds.

The sounds all come from different sources and sound different. But really they are all very similar. Sounds have one thing in common: they all result from some kind of object being set in vibration.

ACTIVITY 7

Sounds don't move, do they?

Work in pairs.

What You Need:

- Talcum powder or flour
- A drum and drum stick
- A tuning fork
- A ping pong ball on a string

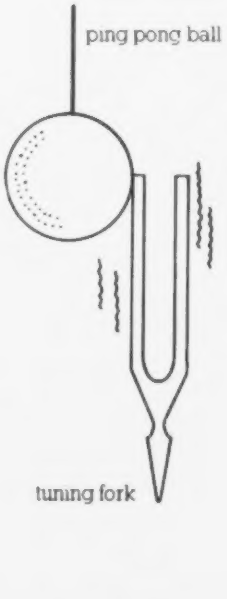
Steps to Take:

1 Set the tuning fork in vibration and hold it up straight.

2 Holding the end of the thread, bring the ping pong ball close enough to touch one prong. What happens to the ball?

3 Now sprinkle some powder on the drum and then beat it. Describe what happens to the powder. Try to explain your observations.

4 Discuss your ideas with a partner.



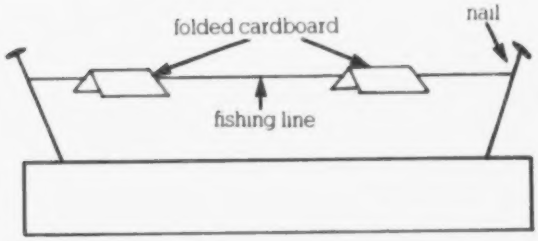
ACTIVITY 8

Can you make this sound?

Work in pairs.

You Will Need:

- A board with two nails in it
- A piece of fishing line
- A piece of stiff cardboard
- Scissors



Steps to Take:

1 Tie the fishing line tightly between the two nails.

2 Pluck the line in the middle. A musical note is produced. Notice that the line is also vibrating.

3 Cut two 3 cm squares from the cardboard. Fold them in half. Hang them over the line, then pluck the string again.

4 Record your observations.

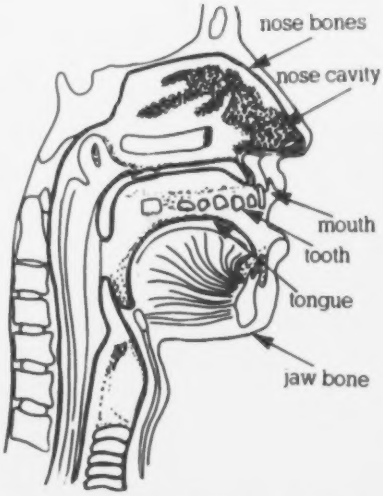
All sounds are produced by vibrations. Our speech is the result of vibrations of the vocal cords in the throat. Air going past the vocal cords makes them vibrate.

To make different sorts of sounds, you stretch or relax your vocal cords. You can also change the sounds you make by stretching other parts of your face.

The loudness of the sound is controlled by the amount of air pushed past your vocal cords.

You now know how sounds are produced, but that still doesn't really explain how the actual sounds reach your ears. Think of yourself in a dinghy floating peacefully on the water. Suddenly a big boat roars past. This boat makes waves that causes your dinghy to bob up and down in time with the waves.

When a plane flies overhead, or a dog barks, the air around them vibrates and sound waves are set up.



Parts of the body used to change sounds into speech

These waves reach your ear-drums and make them vibrate too. Your ear-drums vibrate in much the same way as the dinghy did when the waves in the water reached it.

Your ear-drum is really just a flap of skin, pulled tight over the hollow in your ear. You can think of it like a piece of Gladwrap or rubber balloon stretched over a container.

ACTIVITY 9

Can you feel those vibrations?

Work in pairs.

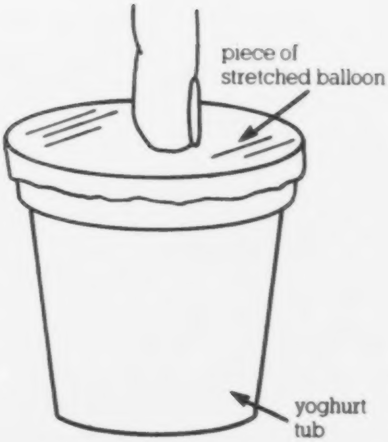
You Will Need:

- One empty yoghurt (or similar) container
- A piece of balloon
- String or rubber band
- A pair of scissors

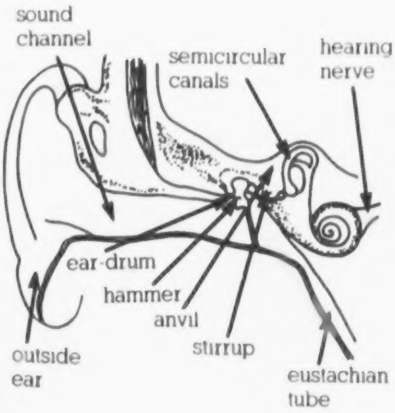
Steps to Take:

1 Pull the piece of balloon tightly over the yoghurt container and secure it with the rubber band.

2 Touch the balloon gently with one finger. Keep that finger there while you make a noise (hitting the desk with your other hand, coughing, etc.).



3 Describe what happens to the balloon.

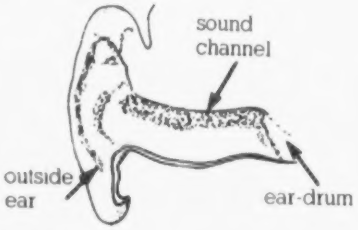

sound channel
semicircular canals
hearing nerve
ear-drum
hammer
anvil
stirrup
outside ear
eustachian tube

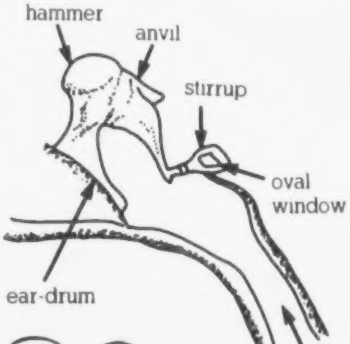
The sound you made sent out waves that made the balloon vibrate, as well as your ear-drums.

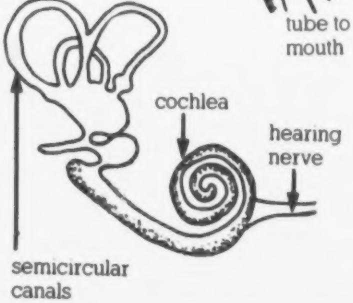
When your **ear-drum** vibrates, it pushes on three tiny bones. These bones are together called the **ossicles**. The ossicles begin to vibrate too, which pushes them on to another small piece of skin. This skin is called the **small inner drum**, or the **oval window**. This also vibrates and makes the liquid in the **cochlea**, a spiral tube, vibrate. From here, the vibrations are felt by special hearing nerves. These nerves send messages back to the brain. The brain makes 'sense' of all these messages as different sounds.

There are three main parts to the ear: the outer ear, the middle ear and the inner ear. Each part has its own role to play:

PART	**FUNCTION**
1 **Outer ear**	It acts as a funnel, collecting sounds for the inside ear. The sound waves travel down the funnel to the ear-drum which vibrates. The ear-drum is in contact with the first of the small bones.
2 **Middle ear**	The three bones – hammer, anvil and stirrup – amplify (make louder) the vibrations and pass them on to the oval window. The bones also amplify the vibrations. There is also a tube leading to the mouth called the **eustachian tube**. It keeps the pressure in the ear the same as the pressure outside.
3 **Inner ear**	The **cochlea** is a spiral tube filled with fluid. The cochlea has sensitive hairs which respond to the sound vibrations. The hairs send the sounds to the brain along the hearing nerve. The semicircular canals help in keeping the body balanced.


sound channel
outside ear
ear-drum


hammer
anvil
stirrup
oval window
ear-drum
tube to mouth


cochlea
hearing nerve
semicircular canals

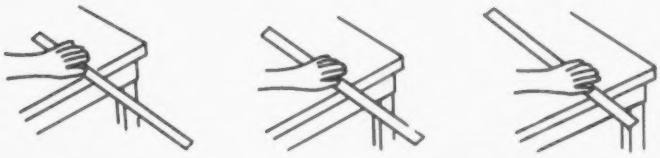
Your ears are very sensitive, and can distinguish between different sounds quite easily. For example, you may refer to the high pitch of a flute, or the low rumble of thunder.

ACTIVITY 10

What sorts of noises can a ruler make?

You Will Need:

- A long ruler
- Bench space



Steps to Take:

1 Hold the ruler on the bench so that there is a lot hanging over the edge. Flick the part of the ruler which is overhanging.

2 Keep shortening the length of ruler hanging over the edge while you flick it.

3 Write down why you think the sound changes as the ruler is moved along the bench. Consider:

(a) the note produced (pitch – how high or low?);

(b) how quickly the ruler vibrates.

You probably noticed the pitch of the sound changes. As you moved the ruler closer to the bench, it vibrated more quickly and the pitch of the sound also increased.

4 Think of a stringed musical instrument. How does this activity relate to playing a stringed instrument?

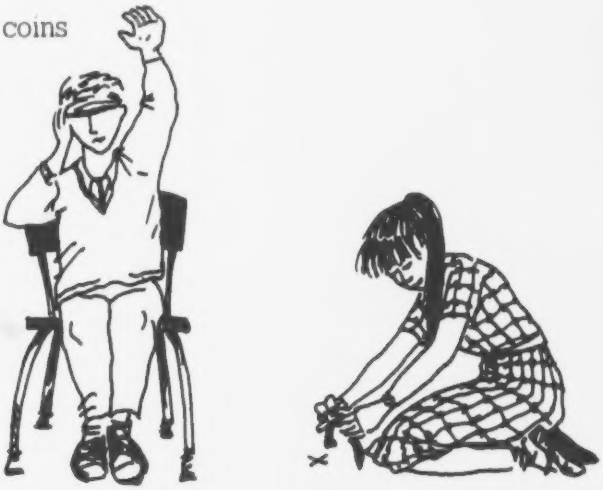
ACTIVITY 11

How well can you hear?

Work in pairs.

You Will Need:

- A blindfold
- A ruler
- A chair
- A funnel
- A loudly ticking watch or two coins
- Some chalk



Steps to Take:

1 Sit in the chair and let your partner blindfold you. Cover your right ear with your right hand.

2 Your partner then walks up to you on your left-hand side holding the watch, or tapping the coins softly. Don't turn your head to hear better. Put up your left hand when you hear the watch.

3 When your hand is raised your partner stops and marks the floor where they stand with the chalk.

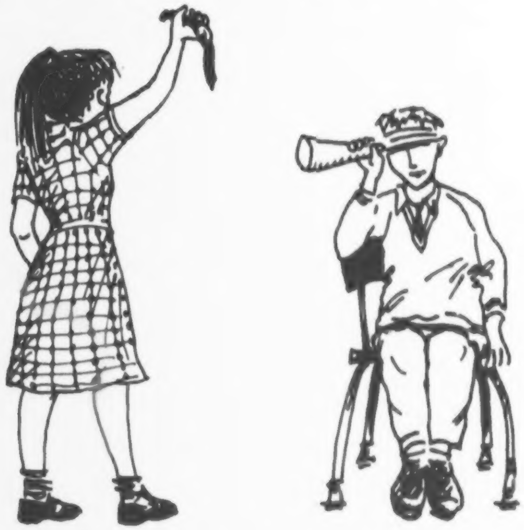
4 Measure the distance from your chair to the chalk mark and record your results on a table like the one on the next page.

5 Now repeat the exercise with your partner approaching you from the other side. Cover your left ear.

	Distance from you to the chalk mark
From the left	
From the right	

6 Now repeat the exercise holding a funnel to your uncovered ear.

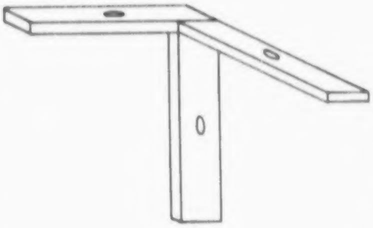
Safety! Don't push the funnel into your ear.



	Distance from you to the chalk mark
From the right with funnel	
From the left with funnel	

You should have been able to hear better with the funnel. This is because the sound waves are channelled into the ear over a bigger space. Your ear needs to be facing the sound.

As well as being a hearing device, your ear contains the balancing mechanism of the body. Balance is adjusted in the **semicircular canals**.

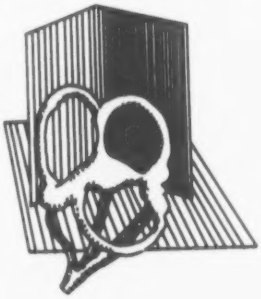


Think of them as three spirit levels working at right angles to one another in three dimensions. (Spirit levels are those gadgets carpenters and bricklayers use to check that what they are building is level.)

Each canal is filled with fluid, just like a spirit level, so any movement by the head affects the fluid. The changes detected by the fluids act on nerves. These nerves then transfer the information to the brain and your body knows what kind of angle it is on.

Sometimes unusual movements upset your sense of balance. When people are sea-sick or car-sick, their balancing mechanism has been upset. If you have ever travelled in a fast lift, you might have noticed a funny feeling.

If you spin around quickly, then you stop, you feel dizzy. This is because the liquid in the canals keeps on moving after you have stopped, just like water keeps spinning or sloshing in a glass after you have shaken it. This continued movement of the liquid in your ears makes you think you are still spinning and you feel dizzy.



Semicircular canals in three dimensions.

ACTIVITY 12

Are you balanced?

Work in pairs. You will need to take turns with others in the class.

You Will Need:

- A revolving chair

Steps to Take:

1 Stand on one foot for 30 seconds. Now close your eyes and stand on the same foot for another 30 seconds. Try the other foot.

Safety! Make sure you do this near a wall, so you can grab it if you feel dizzy.

2 Revolve your partner around 20 times on the revolving chair. Stop the chair suddenly. Ask your partner to walk a straight line!

Safety! Walk with your partner so that you can catch them if they stumble.

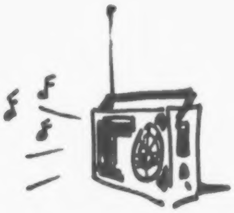
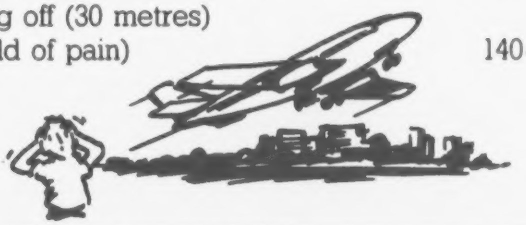
3 (a) Why do you feel dizzy if you jump out of bed quickly?

(b) Why don't ballet dancers get dizzy when they spin?

4 Do some research to find out what training astronauts have to do to cope with movements in space.

People's sense of balance differs, just like their hearing. One thing though that affects people in a similar way is loud noise. Some very loud noises can be dangerous. Some can deafen people.

Sound is measured in **decibels** (dB). Look at the table to get an idea of the loudness scale.

SITUATION	DECIBELS (dB)
breathing	10
radio (music) 	30
two people talking	60
food blender	90
rock band/unmuffled motor bike	100–140
jet taking off (30 metres) (threshold of pain) 	140–150

If you have an instrument to measure decibels, you might like to investigate some common noises.

Any sound that is more than 160 dB can cause instant deafness. Several hours of 120 dB noise can cause temporary loss of hearing. A safety precaution in many noisy working areas is to wear ear-muffs or helmets. Any noise more than 85 dB requires protective devices. Many people don't worry about their ears, but they should! Your ears are extremely sensitive and are very important. Use them wisely.

So we have seen how our eyes and ears enable us to sense things a long way from us. We also considered how the ear helps us to maintain our balance.

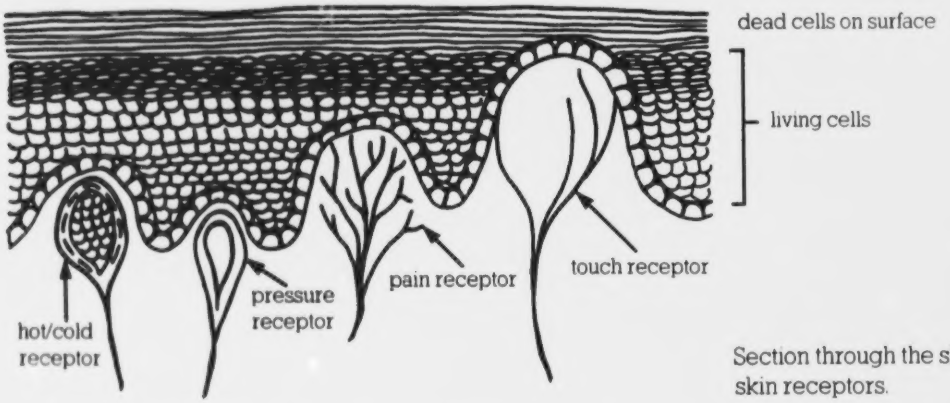
SHORT-DISTANCE SENSES

Touch

'Not so hard!' 'It's too rough!' 'Don't, it hurts!' 'Ooh, it's burning!' 'It's freezing!'

You have probably all said similar things at certain times. Each exclamation refers to a different sensation of the skin: **pressure, touch, pain, heat** and **cold**. These different sensations are felt through certain places on our skin. These places are commonly called skin **receptors**. Nerves connected to the receptors pick up the sensations and send messages to the brain.

Some areas of your body are more sensitive to touch than others. They contain different amounts of receptors, and may contain more of one kind than another.


dead cells on surface
living cells
touch receptor
pain receptor
pressure receptor
hot/cold receptor

Section through the skin showing skin receptors.

Any skin sensation is extremely important for your protection. Without skin sensations you could not feel whether you were burnt or cut.

ACTIVITY 13

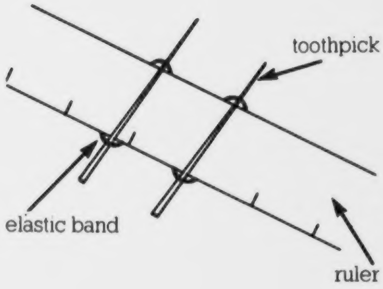
How sensitive are you?

Work in pairs.

You Will Need:

- A ruler
- Two toothpicks
- Two elastic bands
- A blindfold

Steps to Take:


toothpick
elastic band
ruler

1 Set up the ruler and toothpicks like this. Set the toothpicks 1.5 cm apart.

2 Blindfold your partner and touch his/her forearm *lightly* with the toothpicks. Decrease the distance between the toothpicks. When your partner thinks there is only one toothpick present, measure the distance between the toothpicks.

3 Try the same test on different areas of the body and record your results.

Part of body	Distance between toothpicks when only one point is felt
Forearm	

List the parts of your partner's body which were more sensitive than others.

Your heat and cold receptors are sensitive to temperature, but are they always right?

ACTIVITY 14

Feel that heat?

Work in pairs.

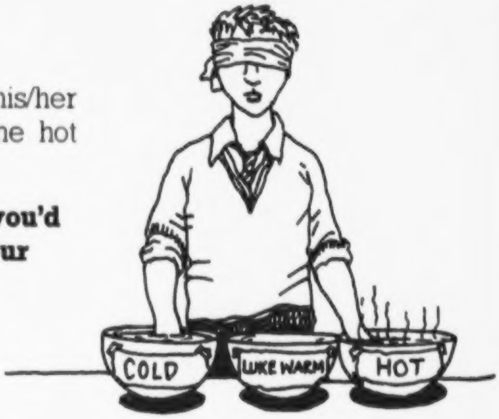
You Will Need:

- A blindfold
- Three bowls
  - one of hot water
  - one of luke warm water
  - one of cold water

Steps to Take:

1 Blindfold your partner then gently put one of his/her hands in the cold water, and the other in the hot water.

Safety! Ensure the hot water is no hotter than you'd have in a hot bath, otherwise you may scald your partner's hand.



Ask your partner if the temperature is the same.

2 Wait one minute, then place both of your partner's hands in the bowl of lukewarm water. Ask your partner if the temperature felt by the two hands is the same. You have fooled yet another sense!

Your fingers and lips are very sensitive to touch. You can probably put something hotter on your arm than your lips. You can feel very fine detail with your fingers, unlike most other parts of the body.

ACTIVITY 15

How good are your feelers?

Work in pairs.

Steps to Take:

Get your partner to cross their second finger over their index finger and put their hand behind their back. Run a pencil through your partner's crossed fingers.

Ask them how many pencils they can feel? Did they say they could feel two?

When your partner's fingers are not crossed, you would have to use two separate pencils to touch the same parts of their fingers that you could touch with only one pencil when they were crossed. So, the feeling given by the brain is that two objects are present.

ACTIVITY 16

Can you tell who it is?

You Will Need:

- A blindfold

Steps to Take:

1 One member of your class should be blindfolded.

2 Now, *silently* choose another member of the class to be the blindfolded person's partner.

3 The blindfolded person should now *gently* feel the face of their partner. Can they guess who their partner is?

4 You could repeat this exercise many times so that most people in the class have a turn.

Probably many of you could not recognise your partner, and found it quite difficult to 'see with your fingers'. But this is how blind people 'see things'.

ACTIVITY 17

What can you tell by touch?

Work in pairs.

You Will Need:

- A box of approximately 20 different materials cut into squares of the same size (e.g. felt, silk, brown paper, sandpaper, plastic)
- A blindfold

Steps to Take:

1 One of you should be blindfolded.

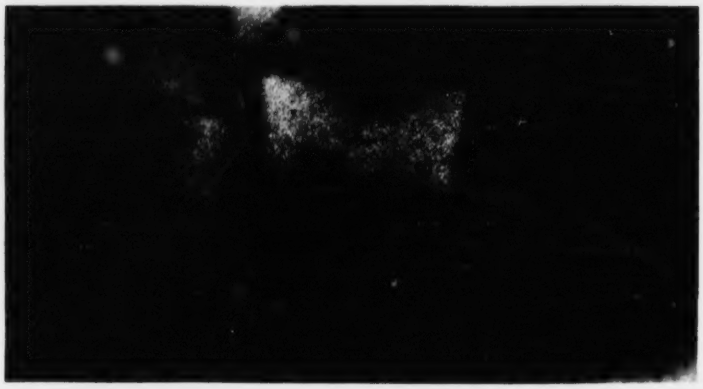
2 The other should give the blindfolded partner five or six samples from the box, one at a time.

3 The blindfolded person should describe the sample to their partner and see if they can identify it correctly.

4 Swap roles, and this time use different pieces of material. Check who comes up with the best score.

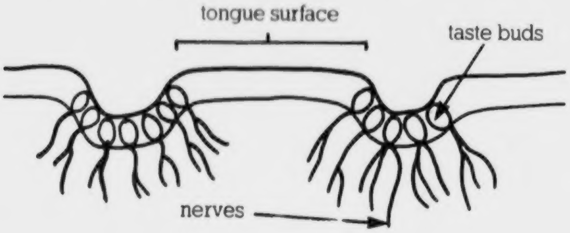
You will probably realise that your sense of touch is very important, but to quite a number of people it is more than that. It acts as their eyes and makes life much easier. Without touch, as well as sight, these people would be even more heavily disadvantaged.

Taste



Your tongue is the sense organ that recognises different tastes for you. Having a tongue allows you to detect common tastes: sweet, sour, bitter and salty.

Your tongue is covered in lots of **taste buds** which are in pits and grooves you can see and feel.

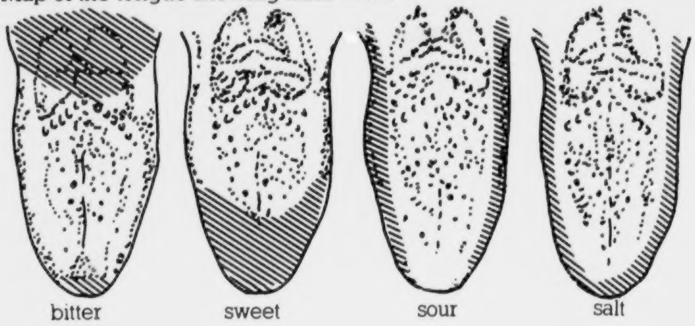


Section of tongue showing taste buds.

Each taste bud has a nerve which sends messages to the brain to indicate what kind of taste is present.

The surface of the tongue is mapped out for tastes. Different parts of the tongue respond to certain tastes.

Map of the tongue showing taste areas.



ACTIVITY 18

Have you got a sweet tooth?

Work in pairs.

You Will Need:

- Glucose solution and a dropper
- Water and a dropper
- A vial
- A Tes-tape
- Toothpicks

Safety! Always be very careful when testing foods in a laboratory. Make sure the area where you are working is clear of all chemicals.

Steps to Take:

1 Place five drops of glucose solution in the vial. Dip the broad end of the toothpick in it.

2 Place a dot on your tongue and a dot on the end of the Tes-tape. Note the sweetness in your mouth, and the colour change of the tape (this may take about a minute).

3 Add ten drops of water to the vial of solution. Now repeat the above procedure. Keep doing this until you cannot taste the sugar any more. If the Tes-tape changes from yellow to a light green colour, then glucose is present, even though you couldn't taste it. (It might take 30–60 seconds to get a colour change.)

Did you find your taste buds a little unreliable? Try the next activity and see just how reliable your sense of taste really is.

ACTIVITY 19

How do you use your senses?

Work in pairs.

You Will Need:

- A knife
- A chopping board
- A blindfold
- Some small pieces of different types of food (e.g. carrot, pear, onion, potato, apple) with different tastes, textures and smells
- Tweezers/forceps

Safety! Make sure that the food is kept clean. If you are allergic to or don't eat certain types of food, tell your partner and make sure that you don't taste these.

Work in pairs. One person should be blindfolded to test the food.

Steps to Take:

1 The tester should taste the foods one at a time and describe out aloud the smell, texture (feel) and taste of each food. The other person can record the descriptions of the food on a table like the one below. Use your own words.

	Description by blindfolded tester		
Name of food	**Smell**	**Taste**	**Feel**
carrot cheese			

2 Repeat the whole exercise, but this time get your partner to hold their nose. Tick whether or not they guessed the food correctly on another table like the one below.

	Holding Nose	
Food	**Guessed correctly**	**Guessed incorrectly**

3 Change places. Use the other set of foods.

4 (a) Did you correctly identify all the foods? If not, which foods did you have difficulty with? Why do you think this happened?

(b) Which of your senses did you use most?

(c) If the tester had a head-cold, would this affect the results?

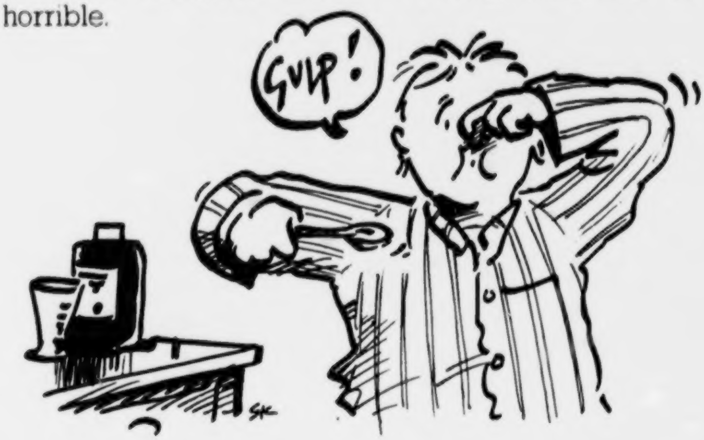
(d) What influence does your sense of sight have on the way you recognise food?

(e) How reliable are your senses?

You will have noticed that it is harder to taste food when your nose is blocked. This is because your senses of smell and taste are very closely related. It is really quite hard to separate the two. When you hold your nose, or when you have a cold, you lose your sense of smell *and* taste. So remember, when you have to take any horrible medicines, pinch your nose. It really will help!

Smell

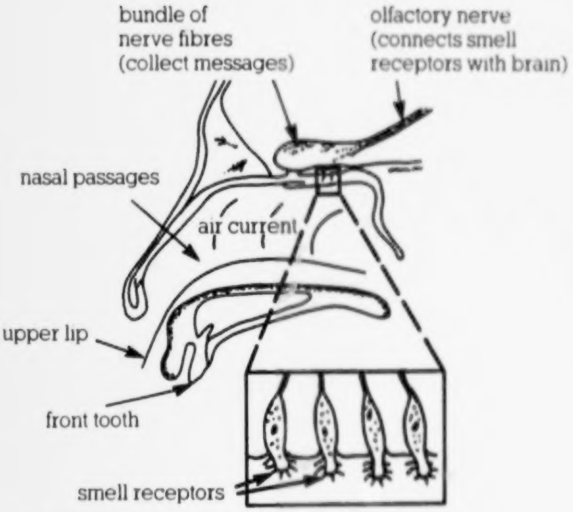
Odours come to your nose through the air. The organs of smell are in the roof of your nose. They contain nerves, which end in very fine hairs. Chemicals dissolved in little drops of fluid (like a vapour) must come in contact with these hairs before you can smell anything. Messages then get sent to the brain, and you then can recognise smells as strong, faint, nice or horrible.



The nerves of smell can become insensitive if they are exposed to the same odour for some time. If you have ever entered a stuffy, smoky room from the fresh air outside, you notice it at once. But the people who have been there for some time do not notice it.

It's lucky we don't rely a great deal on our sense of smell, because it really isn't well developed at all, especially compared with wild animals. Some animals depend on their sense of smell to stay alive. They can smell such things as their enemies, food and water, approaching storms and fires.

Dogs have a very highly developed sense of smell. The police sniffer dogs can find drugs in luggage, or track people over long distances by the smells that they leave.


bundle of nerve fibres (collect messages)
olfactory nerve (connects smell receptors with brain)
nasal passages
air current
upper lip
front tooth
smell receptors

Section through the nose showing smell receptors.

If you have a dog, cat or any other similar animal at home, watch it, and see how often and for how many things it uses its nose.

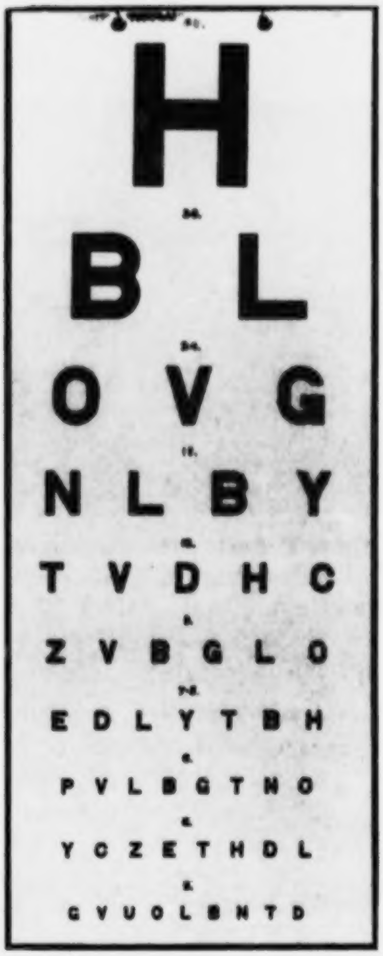
We are sensitive to touch, heat, taste and smell. Through our nervous system we receive information which helps us recognise particular smells and tastes. These senses also help to protect us.

SENSES THAT ARE FAULTY

You have looked at your senses through this chapter and know how important they are. Now think about those people whose senses do not work properly. Some people have problems with their hearing and some with their eyesight.

These people rely far more on other senses, especially touch. Those people who have only partially lost one of their senses may be able to use various instruments to help them gather more information.

Eye defects and blindness



As we've discussed before, not everyone has perfect vision. Some people may need to use glasses or contact lenses to help them see properly.

Other people may be colour-blind and cannot distinguish certain colours. The most common kind of colour-blindness is red/green. This means that the person finds difficulty in distinguishing between these two colours and sees them as shades of grey. Red/green blindness was named after John Dalton, a famous scientist, and is also known as Daltonism.

Most colour-blind people are not aware of their condition until they are tested. A typical test is to look at patterns of red- and green-coloured dots in which there is a symbol, such as a number or letter. Because the colour-blind person cannot tell the difference between the coloured dots, they cannot see this symbol. How might colour-blindness influence your life?

There are hundreds of different eye defects, some not serious, some very severe, which may lead to blindness. Sports injuries cause many eye disorders.

What about total blindness, which could be the result of some disorder or injury? Some people are born blind, and never 'see' anything. Since we depend on vision more than any other sense, blindness is a very serious handicap. Most blind people learn to depend on hearing, touching, smelling and other clues to give them information about their surroundings.

There are many facilities now which help a blind person become more independent. A blind person may use a cane or a trained dog to help them get around.

There are also various types of equipment to help a blind person read and perform other tasks that we take for granted. There is an instrument that scans a printed page with a mechanical eye and translates this into patterns of raised dots that a blind person can recognise and read by touching them. This system is called Braille. Many books, magazines, maps and other reading materials are published in Braille or recorded on cassette.

Other items that help the blind include special watches which allow the wearer to 'feel' what the time is. At modern traffic lights, you will probably hear the clicking of the signs (fast for walk, slower for don't walk). These enable blind people to know whether it is safe to walk or not.

ACTIVITY 20

What is it like to be blind?

Work in pairs.

Steps to Take:

1 Spend a short period of time being blindfolded. You will need a partner to make sure you do not hurt yourself and to give you assistance when you need it.

2 Discuss with your group how you felt. Explain how you relied on your other senses.

Ear defects and deafness

...AGE AFFECTS YOUR HEARING!
...PARDON?

Your ears are very sensitive organs and can be injured in many ways. Your ears may become infected when you have the flu or a cold. Infections, especially **middle ear** infections may threaten your hearing. Your ear-drum could break, and now that you know how important ear-drums are, you know how serious that could be!

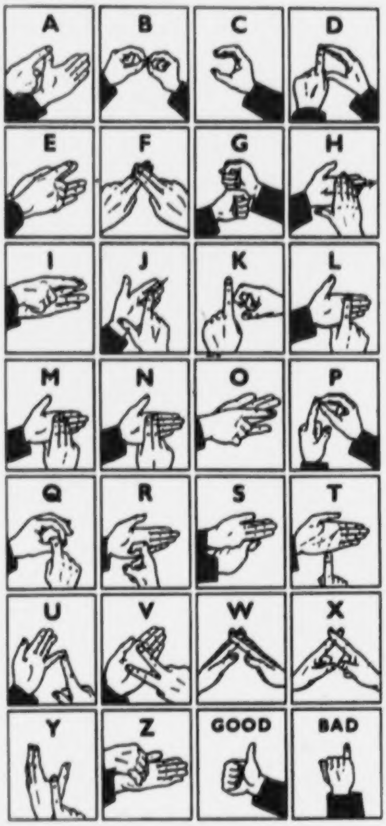
Infections, though, are not the only problem. Changes in old age and various disorders can cause partial or total deafness. Some of these disorders can be helped by surgery or treatment but some, of course, cannot be helped at all. **Nerve deafness** is an example of a disorder that cannot be fixed. The nerves themselves are damaged and they cannot be replaced.

Hearing aides can help in some cases of deafness, but unfortunately they don't work for everyone. So there are still many people who never hear anything. Many deaf people can read lips which enables them to understand what people are saying. Unfortunately many people do not speak clearly, or have beards and moustaches which hide the movements of their lips. This makes it *very* difficult for a deaf person to understand.

Though deaf people cannot hear, many partially-deaf people can still speak though sometimes not very clearly. Others cannot speak at all because they have not been able to learn sounds. These people communicate in a different way, using their hands. This method of communication in called **sign language.**

ACTIVITY 21

Can you talk with your hands?



1 Work in pairs and use the sign language alphabet. Try to write down some simple words that your partner says using this alphabet.

2 Now mime some words, or sentences, very clearly and see if your partner understands. Now say aloud the same sentences but mumble as you speak. See how difficult it is to understand?

3 When you go home and are sitting at the dinner table, try not to speak to anyone. See if you can make

yourself understood by using facial expressions and signs with your hands. Write down all the ways you made yourself understood.

4 Find out about organisations which assist people who are blind or deaf.

5 Find out about some other more recent technical aides which can be used to help blind or deaf people.

If any of our senses are weaker we can use other senses to help us. For example, if we cannot see well, we can use our sense of touch to read Braille. If we cannot hear, we can still communicate with people by using sign language.

SUMMARY

- **There are five major senses: touch, sight, hearing, taste and smell.**
- **The five major sense organs are: skin, eyes, ears, mouth and nose.**
- **The brain is the controller of the body's senses.**
- **Nerves join up to the brain and allow the body to function.**
- **The long-distance senses involve the eyes and ears. They allow us to see and hear at a distance as well as close up.**
- **The short-distance senses involve the nose, the mouth and touch.**
- **The sense organs help us to communicate.**
- **People who lack one or more senses make greater use of the other senses they have.**
- **There are many instruments and aides that help people whose senses don't function fully.**
- **Scientists expand the limits of our senses by using instruments, for example, microscopes.**

REVISION QUESTIONS

1 Explain how your body is able to react so quickly to some situations.

2 (a) How does the eye form an image?
  (b) How do our eyes enable us to read?

3 What are the three parts of the ear and what are their functions?

4 Why do you feel dizzy after spinning around?

5 What enables you to feel the different sensations of the skin?

6 (a) How do you detect tastes?
  (b) What are the four common tastes we can describe?

7 Why aren't humans used to sniff out drugs?

8 List some ways which enable deaf and blind people to communicate more easily.

9 You accidentally put your hand on a hot iron. You withdraw it very quickly. Explain what happens from the time the hot iron touches your hand.

10 Two similar guitar strings, C and E, are plucked in the same way and each produces a sound. String E vibrates faster then string C. Which string, if any, makes the higher sound? Explain why.

11 List safety measures that should be taken to protect your senses.

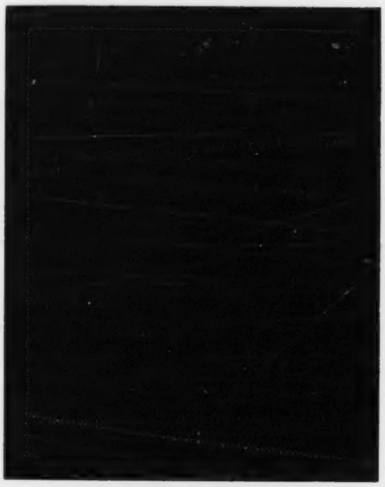
12 How reliable do you consider your senses to be? Give some examples to explain your answer.

4 THE WORLD THROUGH THE MICROSCOPE

Now that you are familiar with the characteristics of living things, we can explore even further. Scientists have made many observations on what makes up living things and why they work as they do. The microscope helps us to extend our sense of sight and to understand living things.

This chapter will help you to answer the following questions:

- How do you focus a microscope?
- What can you see in pond water under a microscope?
- How do you record what you see under the microscope?
- What do crystals look like?
- What are cells?
- What structures are seen inside the cell?
- In what ways are plant and animal cells different?



This is what you might see if you looked at sea water under a microscope. It is magnified about 150 times.

EXPLORING WITH A MICROSCOPE

Living things can be viewed from a distance, close-up or at various stages in between. Each view tells a scientist something different.

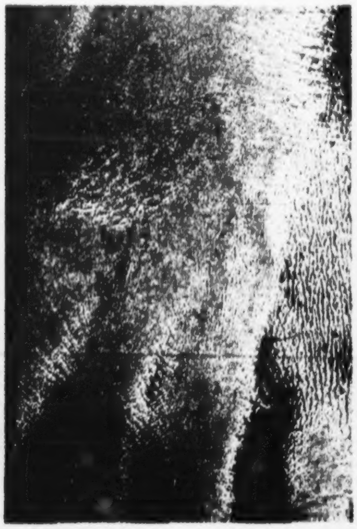
ACTIVITY 1

Can you get any closer?

Steps to Take:

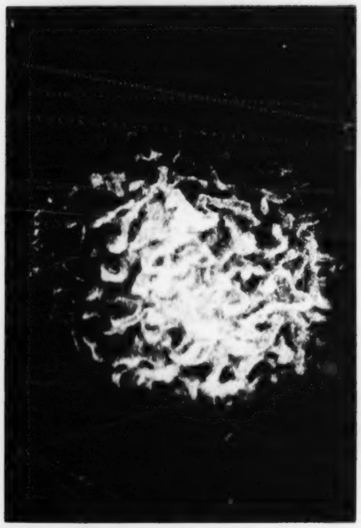
1 Look at the following series of photographs. Each photograph in the series represents a segment of the photograph before in greater detail.

Person asleep **A**



Back of hand **B**

Detail – back of hand **C**

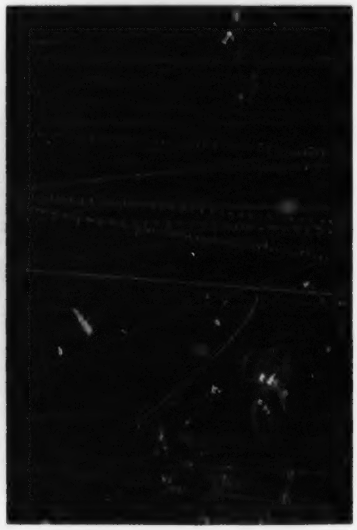


D

In a blood capillary vessel below the surface of the skin

E

Inside a white blood cell



F

Part of material inside the nucleus of the white blood cell.

2 Answer the following questions in your notebook. Leave a space – about a line – after each answer so that you can add to your ideas. Remember you are not expected to know the answers, but you are expected to give *your* ideas. Some things you will learn more about later. Now let's see what the photographs reveal.

(a) What information does Photograph A give you? What are the people doing? Where are they? What is the weather like? What season do you think it is?

(b) Look at Photograph B – a close-up of part of the hand of a person in Photograph A. What does this photograph show? Are there any details you can now notice that you couldn't in Photograph A?

(c) Photographs C shows the detail of the back of a person's hand. What does this photograph show you that you could not see in Photograph B?

(d) Describe what you see in the blood capillary found below the surface of the skin in Photograph D.

(e) Photograph E shows the inside of a white blood cell found in the blood capillary. How much detail can you see?

(f) Have you any ideas about what is shown in Photograph F?

The last activity allowed you to see some different perspectives of living things by **magnifying** them.

Increasing the size of what we see – **magnification** – allows us to see more detail. The microscope is one of the instruments which can been used to take a closer look at life.

Before we look at microscopes, let's see how much we can see with a hand lens or magnifying glass.

ACTIVITY 2
Using one lens

You Will Need:

- A hand lens
- A selection of things like:
  a sample of soil
  some pond water
  insects
  flowers

Steps to Take:

1 Use your hand lens to investigate some of the samples.

2 Talk about what you see with your partner. Are you surprised by anything you see?

The hand lens helped you to see more detail than you normally would be able to. Microscopes use lenses to help you to see even more detail.

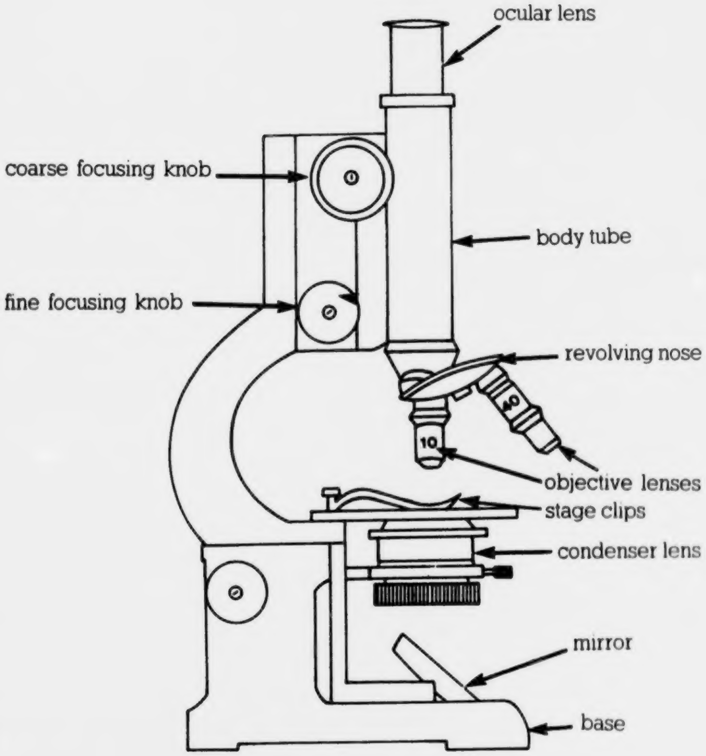
A microscope makes things look larger. It is one of the most important tools of science. An image is formed by passing light through the object being viewed. The image is magnified by lenses. These two lenses are called the **ocular lens** (eyepiece) and the **objective lens**.

The kind of microscope used in most schools has three parts:

(a) **The foot** – the base on which the microscope stands
(b) **The tube** – contains the lenses
(c) **The body** – the upright support that holds the tube.

ACTIVITY 3
Which bit is which?

Different schools use different types of microscopes. The following diagram is labelled to show the main parts of one type of microscope.


ocular lens
coarse focusing knob
body tube
fine focusing knob
revolving nose
10
40
objective lenses
stage clips
condenser lens
mirror
base

Your teacher will show you the main parts of the microscope that you will be using. You will need an outline diagram of the microscope.

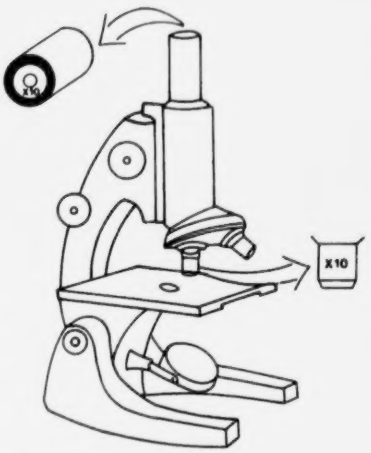
Steps to Take:

When you have been shown the parts of the microscope you are using, label the diagram.

Check the following parts:
(a) eyepiece (ocular lens)
(b) objective lens
(c) stage and stage clips
(d) focus
(f) mirror/light

Magnification

Magnification can be increased by different degrees by using lenses of varying scales. In some microscopes you 'dial' the magnification. In others you need to calculate it.



Check you have identified the two lenses that we are referring to, the one in the eyepiece and the objective lens. Each lens is marked with its magnification power.

You can work out the magnification in the following way.

If the ocular lens is × 10 and the objective lens is × 10, the total magnification of the microscope is 100. This is worked out by multiplying the magnification of both lenses together:

$$(10) \times (10) = 100$$

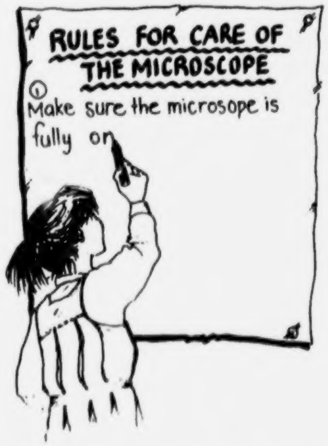
Fill in the missing numbers on the following table.

Magnification of the microscope		
Eye-piece	**Objective**	**Magnification**
× 10	× 10	
× 10		400
	× 20	200
× 5	× 10	
	× 40	200
× 20		200
× 20	× 40	

Microscopes are very costly and certain precautions need to be taken when using them. This next activity will help you to think about taking care of the microscope.

ACTIVITY 4

How do I look after it?

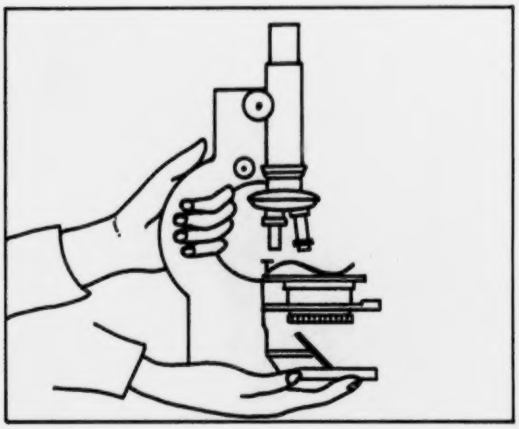

RULES FOR CARE OF THE MICROSCOPE
① Make sure the microsope is fully on

Work in groups of three or four.

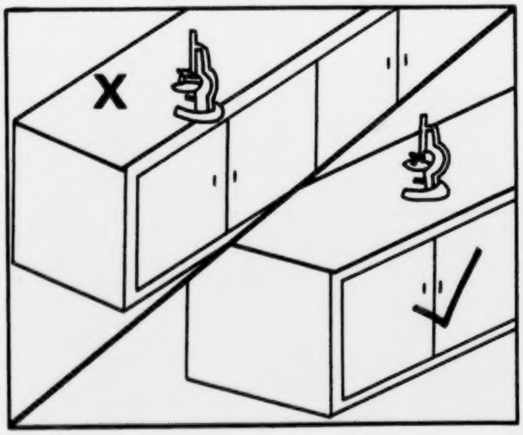
Steps to Take:

1 On the next page are six diagrams of correct and incorrect ways to use and handle a microscope.

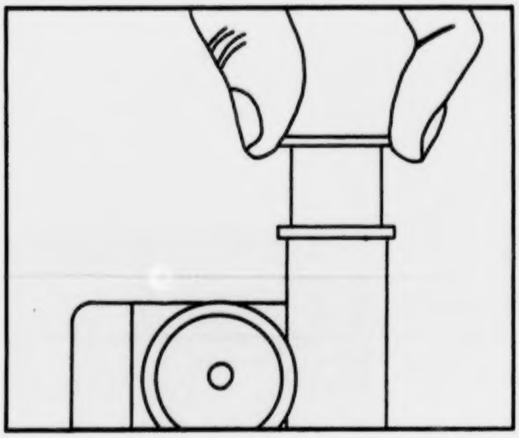
2 Make up a list of rules that you consider important for looking after the microscope. You could discuss these in class and draw up a list of class rules.



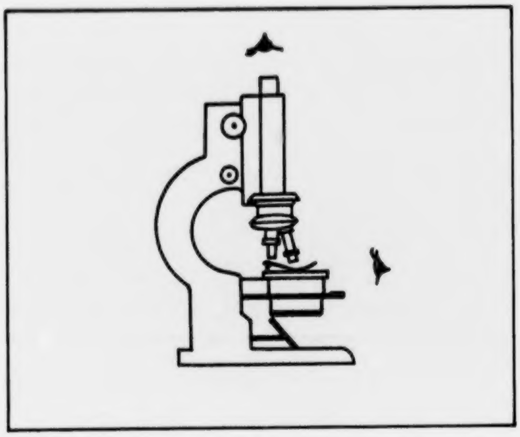
How should you carry a microscope?



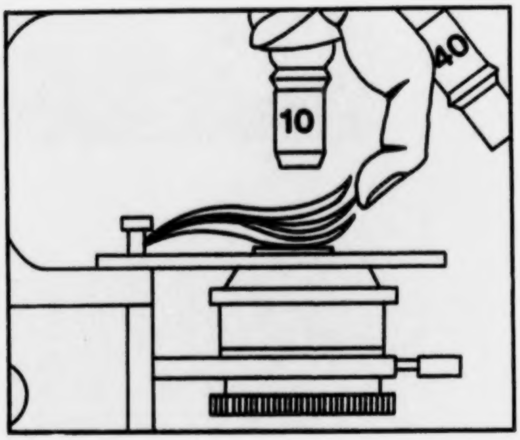
How careful should you be about placing the microscope on the desk or bench?



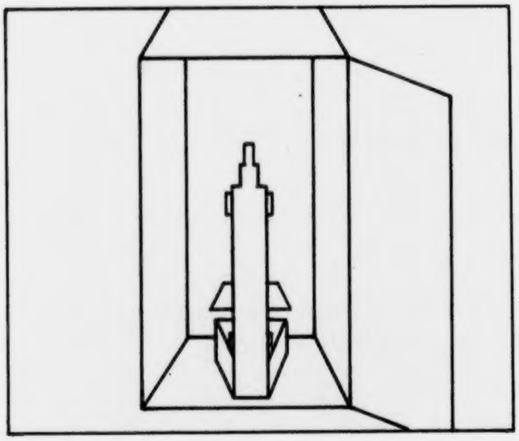
How careful should you be with the lenses?



When should the body tube be moved down?



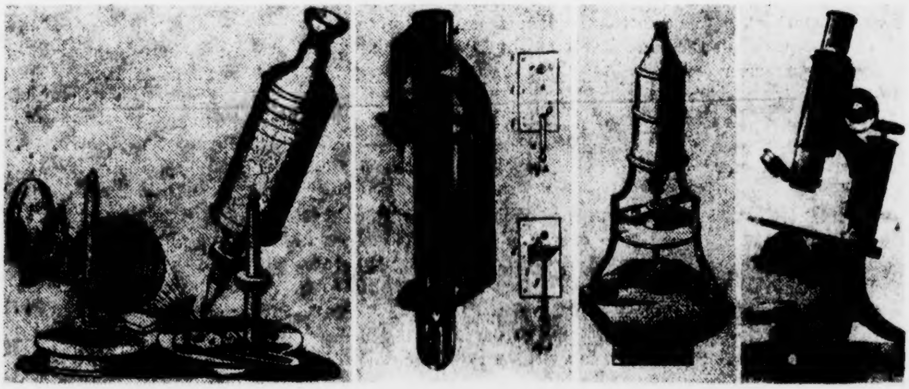
Which objective lens should be focused first?



What should you do with the microscope when you have finished with it?

ACTIVITY 5

What were early microscopes like?



Steps to Take:

1 Compare the pictures of the microscopes. How have they changed with time? What do they have in common? How are they different?

2 Discuss your answers with a partner.

Your teacher may also be able to give you the opportunity of using a stereo microscope to look at such things as hairs, skin around your nails, insects, leaves, flowers and compound eyes.

The stereo microscope could also be used in some of the following activities.

EXPERIMENT 1

What do things look like under the microscope?

You Will Need:

- A microscope or stereo microscope
- A slide
- Pieces of printed newspaper, teased cotton or wool fibres, a piece of film

Steps to Take:

1 Put the piece of newspaper on a slide.

2 Place the slide on the stage and the stage clips on the sides of the slide.

3 Now focus the microscope. Remember to always use low power first and high power second. This is because the high-power lens is very close to the slide and we do not want to damage it.

4 Check with the table on page 106 to find out what magnification you are using. Make a record of it.

5 Describe carefully what you can see under the microscope.

6 Look at the other objects.

7 Discuss what you see with a partner.

EXPERIMENT 2

What lives in pond water, besides goldfish?

You Will Need:

- A microscope and lamp
- A small quantity of pond water
- A dropper
- A slide
- A coverslip
- A toothpick

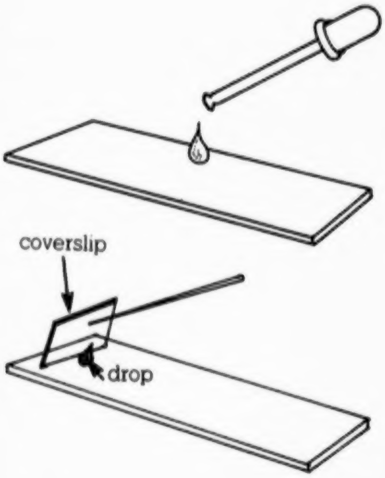
In this activity it has been assumed that your teacher has shown you how to use your particular microscope.

Make sure the lenses are clean. If they are not, use some lens tissue to clean them.

Steps to Take:

1 Use the dropper to put a drop of water on the slide. Don't swamp the slide with water as it will go all over the microscope. Scientists should be neat and tidy!

2 Carefully place a coverslip to one side of the drop of pond water. Slowly lower the coverslip. Use a toothpick to help you. This helps to get rid of air bubbles.



3 Place the slide on the stage and the stage clips on the sides of the slide.

4 Now focus the microscope. Always remember to use low power first and high power second.

5 Check with the table on page 106 to find out what magnification you are using.

6 Look carefully at what you can see under the microscope. How many different animals or plants can you see? Look to see if there are any non-living things.

7 Look again and try to describe the movements of two of the animals.

8 In your notebook, record the magnification that you are using.

9 Draw one of the largest things you can see and then one of the smallest. Try to be accurate about the size.

10 Look at another sample of pond water and record what you observe.

The microscope has given you a new way of looking at pond water. In the next activity, we see how carefully we can observe and record what we observe. We will be looking more closely at the units of life, called **cells**.

ACTIVITY 6

Can you draw exactly what you see?

You Will Need:

- A microscope or stereo microscope
- A dropper
- A slide
- A coverslip
- A toothpick
- A prepared slide
- A dissecting needle
- A piece of tomato

Steps to Take:

1 Make 'tomato squash' or use a prepared slide of cells.

The squash is made in the following way:

- (a) Use the dropper to put a drop of water on the slide.
- (b) Use a needle to remove a small amount of the flesh from below the tomato skin. Place it in the drop of water on the slide.
- (c) Carefully place a coverslip on it as before.
- (d) *Gently* tap the coverslip with the handle of the dissecting needle so that the tissue breaks up.

2 Focus the microscope.

3 Choose part of what you can see and try to draw it as accurately as you can.

Use a well-sharpened pencil, one that is not too hard and not too soft (e.g. HB). This will not tear the paper and it is not too soft to rub out. Use a clear single line and avoid shading so that your diagram looks clear.

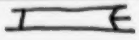
Write the magnification in the corner of the sheet (× 200 means magnified 200 times).

4 Compare your drawings with those of your partner. Are there any ways in which you think you could improve your drawings?

Keep an ongoing record of the different cells you look at by using a table like the one below. An example has been done for you.

Indicate:

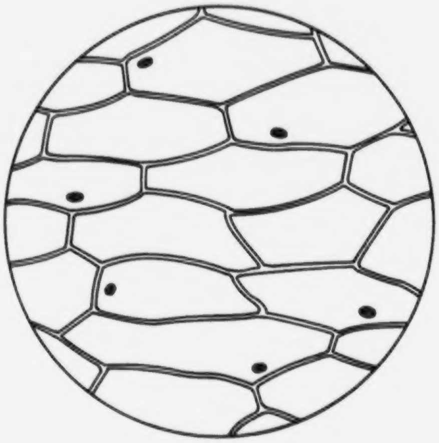
- (a) an outline of the shape
- (b) whether you see thick lines (= cell wall)
- (c) whether you see thin lines (= membrane)
- (d) whether you see a dark area in a cell (= nucleus)
- (e) whether you see other coloured areas (e.g. chloroplasts).

Type of cell	Shape	Thick lines	Thin lines	Dark areas	Coloured areas
Onion		✓	×	In some cells	

Add any cells you saw from your study of pond water to this table.

EXPERIMENT 3

What's in an onion?

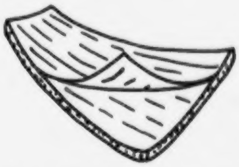


You Will Need:

- A microscope/stereo microscope and lamp
- A piece of onion
- A microscope slide
- A toothpick
- Iodine solution and dropper

Steps to Take:

1 Peel off a small thin piece of onion skin from the inner side of an onion's fleshy bud scale.



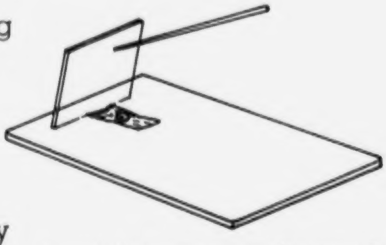
Peel off from the inner side of the bud scale.

2 Lower the inner side of the skin you have peeled off on to the slide. This side is sticky and will stick to the slide.

3 Squeeze a drop of iodine solution on the centre of the onion skin. This will help to make the parts of the cell clearer.

Lay inner sticky side flat on microscope slide. Add a drop of iodine solution.

4 Gently lower the coverslip on to the onion skin using the toothpick.



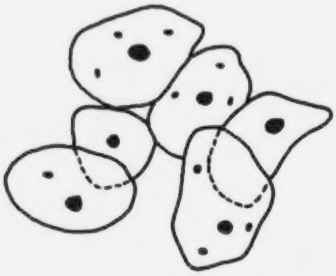
Carefully lower coverslip over the onion skin using a toothpick.

5 Examine the slide under × 40, then × 150 and finally × 300 (use the lowest magnification first). Draw what you see under each magnification.

6 (a) What do you notice about the shapes and sizes of the cells?
  (b) Which diagrams do you think are the most useful?
  (c) What do you think the darkly-stained body is that you can see in some of the cells?

ACTIVITY 7

What do cheek cells look like?



Drawing of cheek cells seen under the microscope.

Steps to Take:

1 Look at the diagram.

2 (a) What do you notice about the size and shape of the cells?

(b) How do the cheek cells compare with the onion cells?

In the next experiment you will look at some chemicals under the microscope.

ACTIVITY 8

What does sugar look like close up?

You Will Need:

- A microscope
- Microscope slides
- Copper sulphate
- Sodium chloride (common salt)
- Zinc oxide
- Coffee
- Sugar

In this activity it would also be useful to use a stereo microscope.

Steps to Take:

1 Place a small amount of each substance on a microscope slide and view under the microscope.

2 Draw an example of each.

3 Is there any way in which you could group these substances?

4 Compare your ideas with those of a partner.

5 Discuss any ways in which a detective might be able to use a microscope in solving cases.

AHA!
...HAVE WE GOT HIM?

We have already mentioned cells. Now let's look a little closer at them.

ACTIVITY 9

What do cork cells look like?

Steps to Take:

Use a microscope to investigate the structure of cork cells in some thin slices of cork. Make a record of how you go about this and note your observations.

So far in this chapter you have looked at the parts of a microscope and found out how to use the microscope correctly. The illustrations in this chapter and the activities you have carried out have shown much more information than what you would have seen using just your sense of sight in the normal way.

CELLS – THE BUILDING BLOCKS OF LIFE

ACTIVITY 10

What else do you want to know about cells?

Steps to Take:

1 Write down how you would describe a cell.

2 Compare your ideas with others. After hearing their ideas, you may like to add to your description.

3 Read the following short history of how cells were discovered.

Anton Van Leeuwenhoek (1632–1723) made a microscope from a lens so he could make objects look larger. He was one of the first people to see living things in what appeared to be only water.

Robert Hooke (1635–1703) was one of the first scientists to use a microscope. He made a close observation of cork. The cork came from the bark of the Cork Oak and had long been used to seal bottles. This is because the cork is spongy enough to be pushed into the neck of the bottle and at the same time it seals the liquid in the bottle from the air.

Hooke discovered that a cork was made up of 'little boxes' like honeycomb. Hooke called these little boxes **cells**. The word cell comes from the Latin word **cella** which means a small room.

In 1839, a scientist named Theodor Schwann wrote a book about living organisms and how they were made up of cells. It was from this work that the cell theory began.

Three ideas that Schwann put forward were:

- All living things are made of cells.
- A new living thing comes from a single cell.
- Living things grow by making new cells.

4 Do you agree with Schwann's ideas?

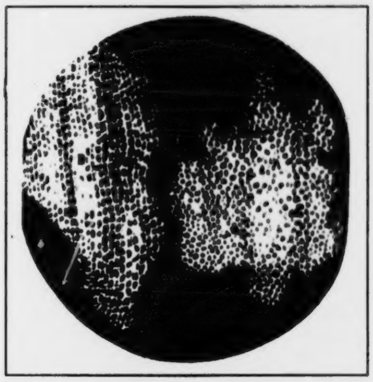
5 Find out more about one of the scientists mentioned above and about their contribution to our understanding of cells and living things. Write some notes on your findings.

6 Some animals and plants are made up of only one cell. Other plants and animals are made up of many cells. Can you guess how many cells make up your body?

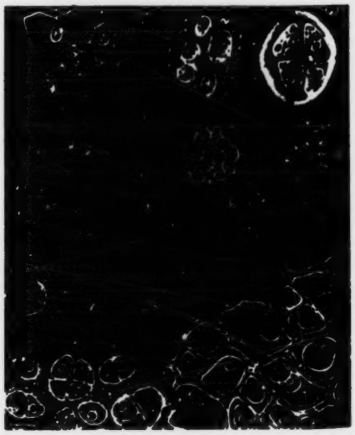
1 000 000 000 000
(a million million)

7 Which living things do you think would be more complex – one-celled plants and animals, or many-celled plants and animals? Why?

Not all cells have are the same **structure** (shape or size). This is because different cells have different **functions** (they do different kinds of work).



Hooke's (1665) drawing showing the cells in cork. This was the first time the cells of a plant had been shown. Hooke and other scientists wondered if all living things could be made up of cells. How does Hooke's drawing of cork cells compare with yours?



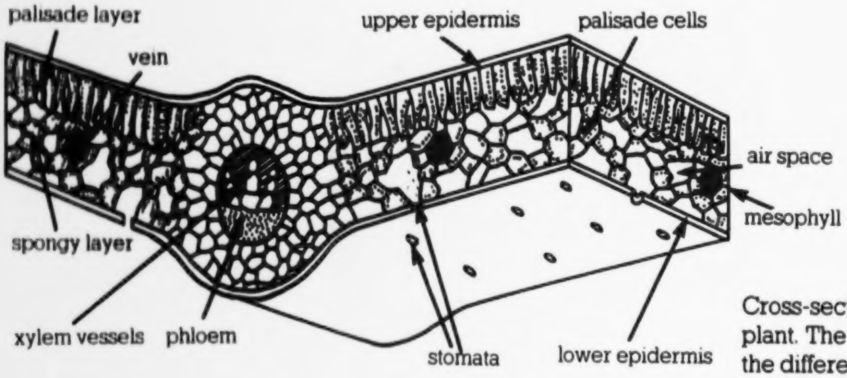
Schwann's drawings of plant and animal cells helped to convince scientists that all living things are made up of cells.

Most cells are so small that they can only be seen under a microscope. Guess how many cells would fit into this letter D? (About 40,000 depending on the type of cell.)

The smallest cells are **bacteria cells.** Some bacteria cause diseases in the body. The largest cells are the yolks of birds' eggs. The yolk of an ostrich egg is the size of a baseball. It is the largest cell of all.

Cells have many shapes. They can look like cubes, coils, boxes, snowflakes, corkscrews, rods, saucers, rectangles or blobs of jelly. However, the one thing that they have in common is that they are all **three-dimensional.**

The **amoeba** is a one-celled animal and has no fixed shape at all. It changes its shape to move around.


palisade layer
vein
upper epidermis
palisade cells
air space
mesophyll
spongy layer
xylem vessels
phloem
stomata
lower epidermis

Cross-section of a leaf of a green plant. The diagram shows some of the different kinds of cells found in leaves.

ACTIVITY 11

What do one-celled plants and animals look like?

You Will Need:

- Culture of one-celled animals and plants (some pond water would do)
- Slides
- Coverslips
- Toothpicks

Steps to Take:

1 Look at some one-celled animals and plants under the microscope.

2 Make some large drawings of four or five different plants and animals. Remember to record the magnification.

3 If the cells move whilst you are watching them, try to describe how they move.

Most cells of many-celled plants are shaped like cubes or cuboids.

ACTIVITY 12

What do cells in some common fruits look like?

Steps to Take:

Investigate the cells of an apple or banana. Add your results to your cell record table.

ACTIVITY 13

How can the sizes of cells be compared?

You Will Need:

- A range of slides with examples of different types of cells.

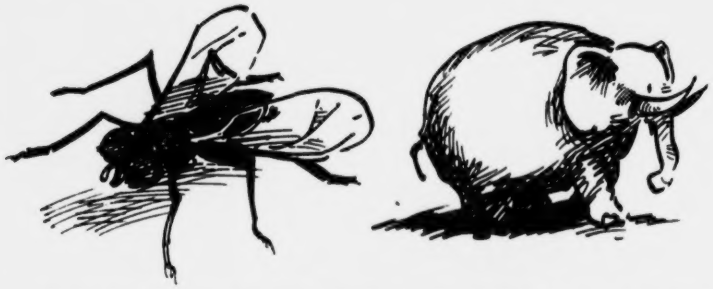
Steps to Take:

1 Think of a way of comparing the sizes of different types of cells.

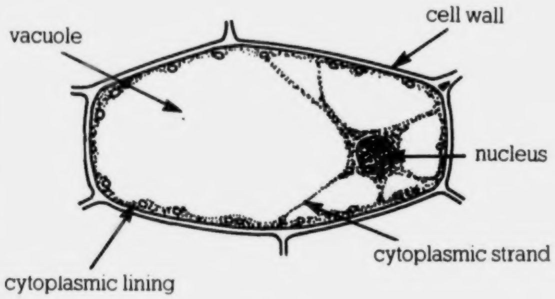
2 Make a record of the comparative sizes of the cells you look at.

3 Was it easy to make this record? How could your job have been made easier?

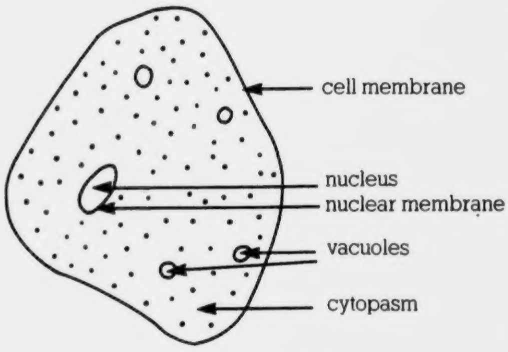
The total number of cells is important, not the size of the cells. The larger an animal the more cells it contains. Of the following two animals, which has more cells?



In some ways all cells are alike, even though they differ in size, shape and how they work. A typical plant and animal cell would be like the drawings below.


vacuole
cell wall
nucleus
cytoplasmic strand
cytoplasmic lining

plant cell


cell membrane
nucleus
nuclear membrane
vacuoles
cytopasm

animal cell

Each cell has a **cell membrane**, a **nucleus** and **cytoplasm**.

The cell membrane

All cells have membranes around them. Because cells are living, they must have food. The food is dissolved in water and passes through the membrane. Wastes dissolved in water also pass out of the cell. The membrane acts like a filter. What is another function of the membrane? (*Hint – why do you carry marbles in a bag?*)

The nucleus

Every cell has a nucleus. The nucleus is the 'ruler' of the cell. It makes the cell do the work it is supposed to do and is usually near the centre of the cell. Have you any idea how the nucleus influences the way you look?

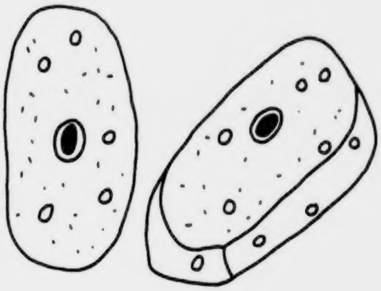
The cytoplasm

The cytoplasm fills the rest of the cell like unset jelly. In the cytoplasm are some small cell parts. We call these small parts **organelles**. The organelles have special jobs to do such as making energy for the cells.

The cytoplasm also contains small round cavities called **vacuoles** which contain fluids. In mature plant cells, there is often one large vacuole which contains fluid and gives shape to the cells.

ACTIVITY 14

Can you make a model cell?



When you look at cells through your microscope, they look flat. Also when we draw things they usually look flat, or two-dimensional. Cells are not really flat but more like little boxes.

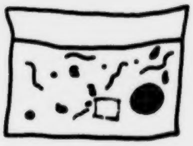
You can make your own cell model with all its inside parts to prove it is not really flat.

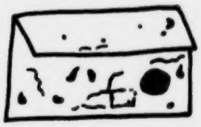
You Will Need:

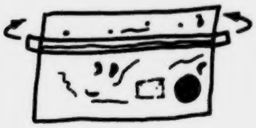
- A small plastic bag – to represent the cell membrane
- Coloured plasticine – to represent the nucleus
- Jelly beans – to represent the organelles
- Shampoo bubbles – to represent vacuoles
- Sticky tape
- Agar or gelatine and water – to represent the fluid cytoplasm

Steps to Take:

1. Carefully half fill your bag with fluid 'cytoplasm'.
2. Add the nucleus, the vacuoles and the organelles.
3. Top up with fluid cytoplasm.
4. Fold the top of the bag and sticky tape it down.
5. Put the cell models made by the other class members together like honeycomb. See how they snuggly fit together and are all similar. Do you have an idea of what a group of the same cells is called?







ACTIVITY 15

Plant and animal cells – Is there a difference?

1 Look closely again at the pictures of a plant and animal cells on p. 118. Use these, and the record you have made of the cells you have studied to answer these questions.

2 (a) Do both plant and animals cells have a membrane around them?

(b) Some cells have a **cell wall** around the cell membrane. The cell wall is made of cellulose with many fibres meshed together – like the material of a closely woven basket. Which cells have a cell wall?

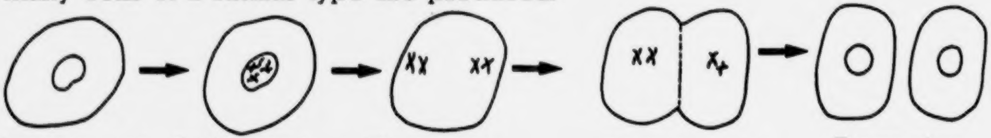
(c) What differences are there in the cell contents? Do both have similar vacuoles?

Chloroplasts are the microscopic parts of plant cells which contain the green colouring matter called **chlorophyll**.

Cells need water, food, and to be kept at a correct temperature.

Water carries food to cells and carries away waste products. Cells must have food. Without food, there can be no energy and the cells die. The temperature must not be too hot or too cold. Most living things like a temperature between 5°C – 45°C. Why?

When a cell becomes mature it will divide to produce two new daughter cells. This is known as **mitosis** (my-toe-sis). The two new daughter cells are identical. They started life as one cell. When the daughter cells mature they also divide. In this way, many cells of a similar type are produced.



A mature animal cell before mitosis.

Small 'threads' can be seen in the nucleus.

The 'threads' move either left or right after the nuclear membrane dissolves.

The cell begins to split into two halves.

Two exact daughter cells. These will also mature and divide.

New cells are needed if things are to grow. They are also needed when old cells wear out and die and to replace those which are damaged and killed. The dead cells from our outer skin are continually being lost and replaced by new cells. When the skin is damaged, cells grow to repair the skin.

The cells of a living thing are not all the same. Most are **specialised**, which means that they have one special job. Nerve cells, for example, often have long extensions so that messages can be transported from one part of the body to another (see Chapter 3).

When all of the cells for one job are grouped together they are called **tissues**, for example muscle tissue is made up of many muscles cells that all do the same work - help move the body.

SUMMARY

- **The microscope is a powerful instrument. It enables us to extend our sense of sight and look at microscopic things such as cells and crystals so that we can study them in detail. The microscope has led to many scientific discoveries.**
- **The microscope has three major parts:**
  - **(a) the foot (the base on which the microscope stands);**
  - **(b) the tube which contains the lenses; and**
  - **(c) the body (the support which holds the tube).**
- **The magnifying power of the microscope comes from the lenses found in the eye piece and the objective lens.**
- **The magnification of the microscope is worked out by multiplying together the magnification of each of the lenses.**
- **The microscope is an expensive instrument and it needs great care in the way it is handled.**
- **When drawing things seen under the microscope care should be taken:**
  - **(a) in selecting a good example for drawing;**
  - **(b) in drawing clearly; and**
  - **(c) in showing the magnification.**

- **All living things are made of cells. A new living thing comes from a cell, and living things grow by making new cells.**
- **All living cells have a nucleus. Plant cells differ from animal cells in that they usually have a cell wall (usually composed of cellulose), a large vacuole with cell sap, and chloroplasts.**
- **Cells may vary in their size. They may have different functions. Cells with similar structure and functions together form tissues.**

REVISION QUESTIONS

1 Pretend that you are introducing the use of a microscope to a friend. List some important ways of caring for the microscope.

2 The following table shows how the magnification of the microscope is worked out. Record the missing data in your notebook.

Eyepiece	Objective	Magnification
× 10	× 40	
	× 10	× 200
× 10		× 100

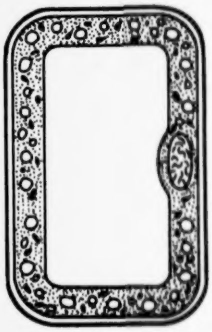
3 You are asked to find out whether a sample of water has any animal life.

(a) List the equipment/materials you require.

(b) Describe the stages in preparing a sample of water to view under the microscope.

(c) How would you determine whether there are plant cells or animal cells in the sample?

4 Look at the following drawing of a newly-found cell.



Is it an animal cell or a plant cell? List your reasons.

5 The following is a photograph taken viewing down a microscope.

Select one of the organisms and make a careful drawing of what you see.

Now make a careful drawing of one of the cells in this photograph.

State in each case whether it is an animal or a plant cell, and explain why.

5 WATER

Water is the most common substance on the earth. Oceans, rivers and lakes cover more than 70 per cent of the earth's surface. Water is also found in the ground and in the air we breathe.

Like air, water is a very important part of our lives. Without it there would be no life on earth. All living things must have water to live. Both plants and animals are mostly made up of water, in fact, water makes up two thirds of our bodies.

Did you think water could look like this?

There are many things that we could study about water, but in this chapter we will look at just a few. By the end of the chapter you should be able to answer such questions as:

- What is the boiling point of water?
- What happens to water when it boils?
- What are the advantages of cooking vegetables in a steamer?
- What happens when you add salt to ice?
- Are some substances more soluble in water than others?
- How can I investigate more about water?
- How can I grow crystals?

INVESTIGATING WATER AND HEAT

ACTIVITY 1

What do you want to know about water?

Steps to Take:

1 List any questions about water that you would like to have answered.

2 Discuss your questions with a partner. You may come up with other questions about water. Make a list of all the questions you would like answered.

You may remember that one way scientists investigate substances is to heat them. Let's do just that. This should test your powers of observation.

EXPERIMENT 1

What happens when water is heated?

You Will Need:

- A heat proof mat
- A 250 mL beaker (any similar size one will do)
- A Bunsen burner
- A gauze mat
- A spatula
- A test-tube
- A test-tube holder
- A cloth to handle the hot beaker
- A tripod
- Anti-bumping granules
- Potassium permanganate crystals

Steps to Take:

1 Add about 3 cm of water to the beaker.

2 Heat the water gently until it boils, making careful records of all your observations. What happens before boiling? Describe carefully what happens as the water boils.

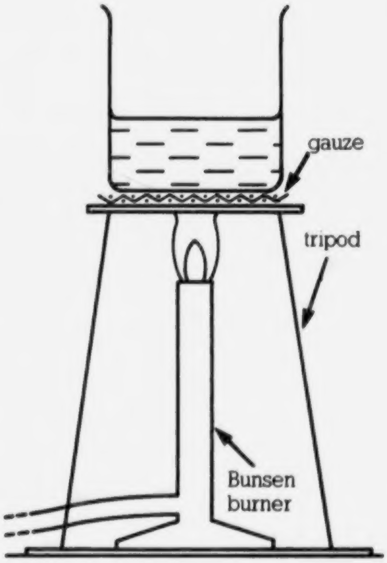
3 Add some anti-bumping granules. Describe what happens.

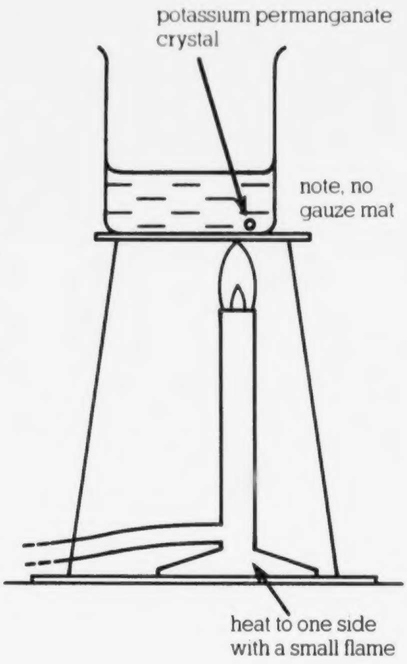
4 Hold a cold test-tube with a test-tube holder over the steam for a few seconds. What do you observe? How could you check out your observation?

5 (a) What effect did the anti-bumping granules have on the boiling water? Why add them to boiling liquids?

(b) What do you think the bubbles are? How could you check your answer?

6 Heat another beaker of water, but this time do not use a gauze mat and heat the beaker *very gently* from one side.




potassium permanganate crystal
note, no gauze mat
heat to one side with a small flame

7 Using a spatula, add a small crystal of potassium permanganate to the side of the beaker being heated. Record what you observe.

8 (a) What happens to the water around the potassium permanganate crystal?
  (b) Draw a diagram showing the movement of the colour from crystal. What does this tell you about how heat travels? Explain why.
  (c) Can you think of any ways in which you could make use of this idea? (That is, the idea of water or other fluids being used to circulate heat.)

EXPERIMENT 2

What is the boiling point of water?

Work in pairs.

Steps to Take:

1 Work out what equipment your pair will need.

2 Think about how you will carry out the experiment:
  (a) Will it be better to heat the water slowly or quickly?
  (b) Will you need to stir the water?
  (c) From your previous observations, when will you judge the water to have boiled?
  (d) How can you make sure your temperature reading is accurate?

3 Write a paragraph to explain what you have done.

4 Compare your result with that of other groups.

When the water boiled you could see it formed steam. When steam forms there is a process happening called **evaporation**. In the next activity we will observe what happens to steam when it is cooled.

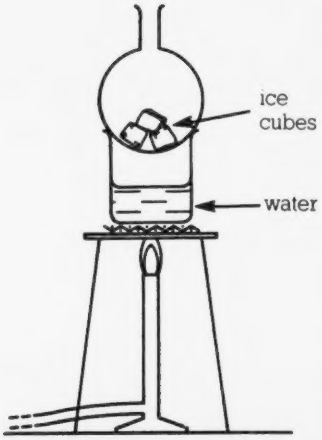
EXPERIMENT 3

What happens when steam is cooled?

This could be done as a demonstration, or you could work in groups of three or four.

You Will Need:

- A 400 mL beaker (250 mL will do)
- A Florence flask
- A tripod stand
- A Bunsen burner
- A gauze mat
- three or four ice cubes



Steps to Take:

1 Put the ice cubes in the flask.

2 Half fill the beaker with water and stand it on the gauze mat on top of the tripod stand.

3 Light the burner and use it to boil the water.

4 When the water is boiling, rest the flask containing the ice cubes on top of the beaker of boiling water. Observe carefully.

5 (a) What happens to the water boiling in the beaker?
(b) What forms on the bottom of the flask?
(c) What happens to the material that forms on the bottom of the flask?

6 Compare your answers with those of others in your group.

7 Now let's compare what happened in this experiment with what happens to water in seas, lakes and the soil.

8 Can you answer the following questions?

- What heats up the water in the sea, lakes and soil?
- What happens to the water vapour/steam?
- Where does rain come from?

Where does the rain come from?

What is happening?

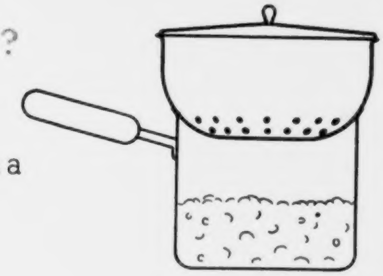
If you cannot answer these questions straight away, do some research. Look up words like **evaporation** and **precipitation**.

In the next activity we can look at how steam is used for cooking. This can be compared with the more traditional way of boiling vegetables in water. Your teacher may like you to try this out at home.

What are these clouds made of?

EXPERIMENT 4

Do steamed vegetables taste different?



You Will Need:

- A steamer (or you can use a colander which sits in a saucepan)
- A saucepan and lid
- A range of vegetables, e.g. beans, celery, carrots

Steps to Take:

1 Prepare some vegetables for cooking. Cut the beans and celery into similar lengths and dice the carrots into cubes of roughly the same size. Why do we want them to be of similar size?

2 Divide the vegetables you have prepared into two equal-sized portions.

3 Cook half of the vegetables in the steamer for about 10 minutes and boil the other half in water for 10 minutes.

4 Compare the two lots of vegetables:

(a) Are they the same colour?

(b) Have they the same texture? (Try chewing some to find out.)

Safety! Remember to be careful with food in the laboratory.

(c) Do they taste alike?

(d) Check the water in the steamer and the water you boiled the vegetables in. Have the vegetables lost anything to the water?

5 Write a paragraph describing what you have found out from for your experiment.

6 See if you can find out any more about the advantages/disadvantages of steaming compared with boiling of vegetables.

7 Write a short newspaper article reporting what you have found out about steaming and boiling vegetables.

8 Now conduct a small survey of say 10 households to find out how often the occupants use a steamer and why (or why not). You could pool the results with those of other students in the class.

Sometimes you can find out more about a substance by comparing it with something else. In the next activity you can compare oil and water. Your teacher will demonstrate Part 1 of the following experiment.

EXPERIMENT 5

How does oil compare with water?

Your teacher will do Part 1 as a demonstration. Work in groups of three for Part 2.

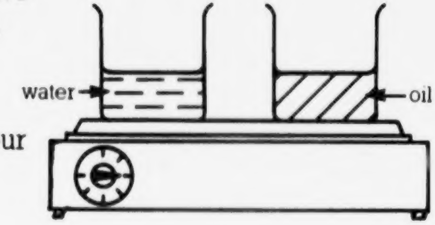
You Will Need:

- A hot plate
- Two small beakers
- Two thermometers
- Oil (vegetable oil will do)
- Water
- Two test tubes
- Two ball-bearings
- Two white tiles

PART 1 Which liquid will boil first?

Steps to Take:

1 Try to predict what will happen before your teacher begins the experiment.



2 Your teacher will heat equal amounts of the two liquids on the hot plate as shown in the diagram.

3 Describe what happens.

4 Try to explain what you observed. Discuss your ideas.

PART 2 How do the liquids flow?

Steps to Take:

1 Write down any differences you can observe between the look and smell of the oil and water.

2 Drop a little of the oil on to a white tile and a little of the water on to another white tile. Describe how they flow.

3 Make a prediction about what will happen if you were to drop a ball-bearing into a test-tube of oil and one into a test-tube of water at the same time. Try it. What do you observe about the speed at which the ball-bearings fall through the two liquids?

4 Write a paragraph describing the similarities and differences between the flow of water and oil.

PART 3 What other differences are there?

- Do you think that the masses of equal volumes of oil and water would be the same?
- What would happen if you put a drop of water into a test-tube of water?
- What would happen if you put a drop of oil into a test-tube of oil?
- What would happen if you added a stone and a cork (solids) to each test-tube of oil and water (liquids)?

Now devise ways of finding out if your predictions are correct. Remember not to waste the oil.

For each experiment:

(a) record your prediction – **hypothesis**
(b) record how you went about your work – **method**.
(c) record your what you saw – **observation**.
(d) record what you have learned from your experiment – **conclusion**.

Then make a summary of your findings. Explain why they did or did not support your predictions.

You should now be able to answer the following questions:

(a) In what way is oil more useful than water? Explain, relating your answer to your findings.

(b) Think of some ways of separating oil from water. Write down your ideas.

EXPERIMENT 6

What is the temperature of ice?

Steps to Take:

1 Work out what equipment you will need.

2 Think about how you will carry out the experiment:
   (a) Will it be better to use large lumps of ice, or ice that has been crushed up?
   (b) How long will you wait before you read the temperature?
   (c) How can you be sure your temperature reading is accurate? Should you take more than one reading?

EXPERIMENT 7

What happens to the temperature of ice when salt is added to it?

1 Predict what will happen to the temperature of ice when salt is added to it?

2 Carry out the experiment and record your observations.

3 How do you think this information could be useful to us?

ACTIVITY 2

So, what else is there to know about water?

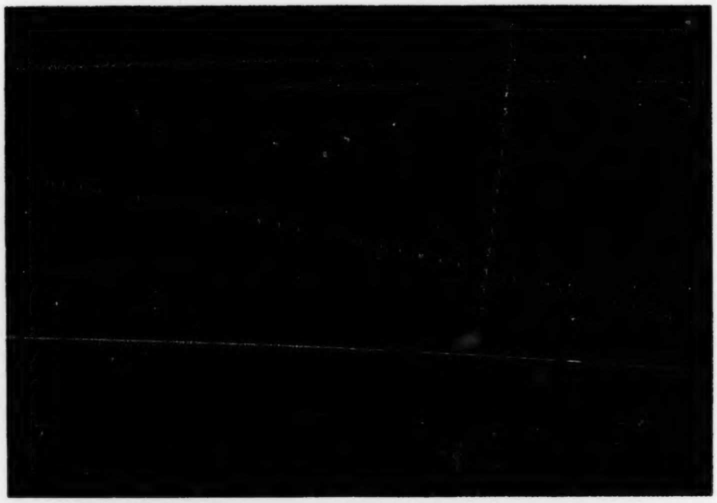
Choose one of the following topics. Do some research and prepare a three-minute talk for your group or the class.

1 Why is the water in your body so important?

2 Describe the water cycle. How does it affect our daily lives?

3 How has water been used to produce energy?

4 How has water been involved in transportation?



So far you have observed water being heated and have measured its boiling point. You have seen that steam, when cooled, condenses to water. You have compared the effect of steaming and boiling on the taste of vegetables. You have also compared the properties of oil and water and investigated ice and the effect of adding salt on its temperature.

SOLUTIONS

When we are thirsty we not only drink water, but other things like cordial. The cordial contains water with dissolved solids such as sugar and flavouring. When a solid is dissolved in a liquid a **solution** is made. So we drink many different solutions.

A solution is a mixture in which dissolved bits of solid are apread evenly through the liquid but they are much too small to by seen.

In this section you will be able to investigate what happens when you add some substances to water. First of all, let's look at sugar.

EXPERIMENT 8

What happens when you add sugar to water?

You Will Need:

- A test-tube
- Sugar
- A spatula

Steps to Take:

1 Add a small amount of sugar to a third of a test-tube of water.

2 Record your observation.

3 How do you explain your result?

When a substance dissolves in water it is said to be **soluble**. The substance added is called the **solute** and the substance in which it dissolves is called the **solvent**.

In Experiment 8 the solute was sugar and the solvent was water.

We can think of the sugar crystals as being made up of little bits, or **particles**. The particles are held very closely together in a crystal of sugar. When sugar is added to water the particles loosen and separate in the water. The particles are so small in the solution that they cannot be seen.

Solubility is another method scientists use to identify substances. Have a close look at sodium chloride (common salt) and potassium nitrate in the next experiment. They probably look the same to you, but are they both as soluble as each other in water?

EXPERIMENT 9

Which substances dissolve in water?

This is an experiment in three parts. Your teacher will demonstrate Part 2.

You Will Need:

- A Bunsen burner
- A ceramic mat
- A test-tube rack
- Eight test-tubes
- Distilled water (if available)
- A gauze mat
- A tripod
- A 100 mL beaker
- A watch glass
- A teat pipette
- Labels
- Small quantities of potassium nitrate, glucose, iodine, paraffin wax, sulphur, naphthalene,. sodium chloride, potassium chlorate

Steps to Take:

PART 1

1 Half fill each test-tube with water (distilled preferably).

2 Add about half a spatula of each substance separately to each test-tube.

3 Shake each test-tube. Feel the test-tube with your hand to see whether the solution changes temperature.

Don't forget to label your test-tubes as you will need the solutions for Parts 2 and 3.

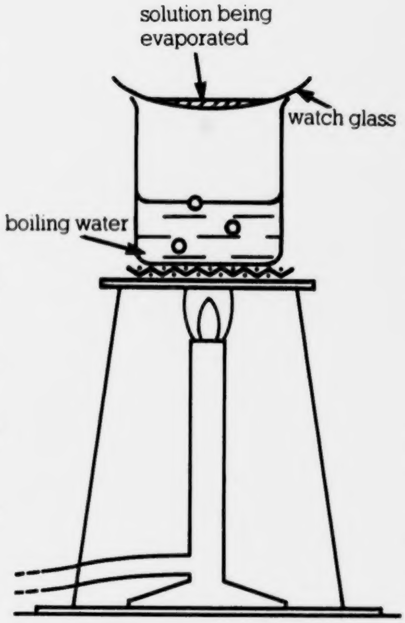
4 Examine the substances in each case and decide which substances are insoluble in water, which are only slightly soluble, and those which are very soluble in water. Record your results on a table like the one below.

Name of substance	**Solubility of substances in water**		
	Insoluble	Slightly soluble	Very soluble

PART 2

5 Take two or three drops of each solution using a teat pipette and place on a watch glass. Evaporate the liquid by placing the watch glass over a beaker of boiling water. Record your observations.

What did you notice about the very soluble substances? How do you explain your observation?



PART 3

6 Repeat Part 1 using kerosene instead of water.

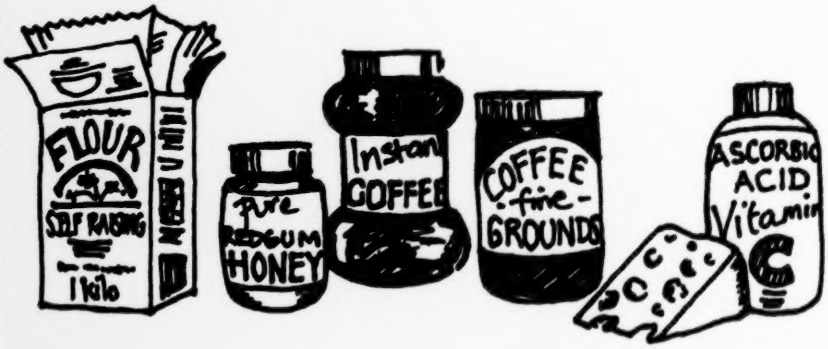
7 Compare the solubility of substances in water and kerosene.

8 (a) Were the substances which were very soluble in water also very soluble in kerosene?
  (b) Which substances were soluble in kerosene? Were they also soluble in water?
  (c) Write down any ideas which might explain your observations.

Now let's compare the solubility of some common substances.

EXPERIMENT 10

How soluble are certain foods?


FLOUR
SELF RAISING
1 kilo
Pure
REDGUM
HONEY
Instant
COFFEE
COFFEE
-fine-
GROUNDS
ASCORBIC
ACID
Vitamin
C

1 Investigate the solubility of some foods, e.g. flour, honey, coffee, cheese and ascorbic acid (vitamin C), by testing them in water.

2 (a) Which foods were most soluble?
  (b) What happens to soluble foods when we eat them?
  (c) What happens to insoluble foods when we eat them? Write down some of your ideas.
  (d) Compare your ideas with others in the group.

EXPERIMENT 11

Does temperature affect the solubility of sugar?

1 Find out how many teaspoons of sugar can be dissolved in a small beaker of water.

2 What happens to the solubility of sugar when the temperature is increased?

3 What happens to the level of water in a beaker when you add 12 teaspoons of sugar?

Write a report on what you have found out. Try to explain what you have observed.

EXPERIMENT 12

Does temperature affect the solubility of other substances?

This experiment should be done as a class demonstration.

You Will Need:

- 5 g sodium chloride
- 5 g potassium nitrate
- Two test-tubes, 20 mm × 140 mm, with stoppers to fit
- A test-tube rack
- A 250 mL beaker
- A gauze mat
- A Bunsen burner and stand or hot plate
- Any substances you wish to test

Steps to Take:

1 Add about 3 cm (about 10 mL) of water to each test-tube.

2 Add the sodium chloride and potassium nitrate separately to each of the test-tubes.

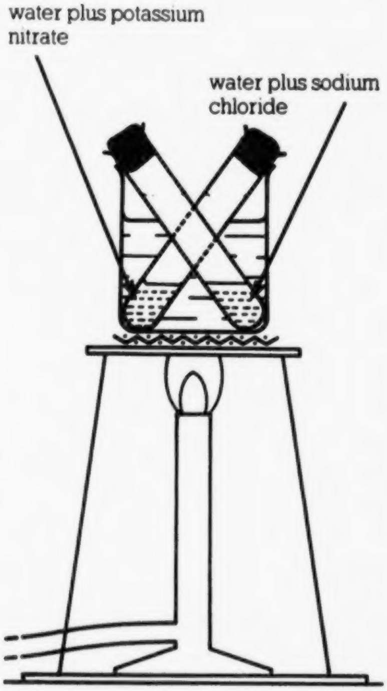
3 With the stoppers on, shake the test-tubes vigorously for about five minutes. Record your observations.

4 Put the test-tubes in a beaker of water and bring the water to the boil. Remove the stoppers. Record what you observe.

5 Remove the test-tubes and allow them to cool in a beaker of cold water. Record your observations.

6 Describe how you could use what you have observed to separate one substance from another.

7 You might now like to test some other substances.



You have seen that some substances are much more soluble in water than others. You have seen that solubility usually increases as that temperature increases, and you have investigated the solubility of some common substances.

MAKING CRYSTALS

A solute is made up of many particles. In sugar for example, the particles are held tightly together to form crystals. When sugar dissolves in water, the particles in each sugar crystal loosen and spread throughout the water. Because the separate sugar particles are so small, they cannot be seen in the sugar solution.

Many substances are made up of crystals. If you look at sugar or salt with a hand lens you can see the crystal shapes. At the begining of this chapter you saw a photograph of water in the form of ice crystals.

Experiment 13

Can you grow crystals?

You Will Need:

- Copper sulphate
- A 250 mL beaker
- A small glass jar with a screw-top lid. It must have a wide neck.
- Cotton thread
- Bunsen burner, tripod and heat proof mat (or hot plate)
- A piece of cardboard
- A hand lens
- A plastic teaspoon
- A stirring rod
- Tissue paper
- Scissors
- A match stick or toothpick
- An ice-cream container or a similar container in which to put the jar

Steps to Take:

1 Half fill the beaker with water.

2 Add copper sulphate to the water, teaspoon by teaspoon, stirring all the time to dissolve it.

3 Keep adding copper sulphate until no more will dissolve and there is some in the bottom of the beaker. This is a saturated solution.

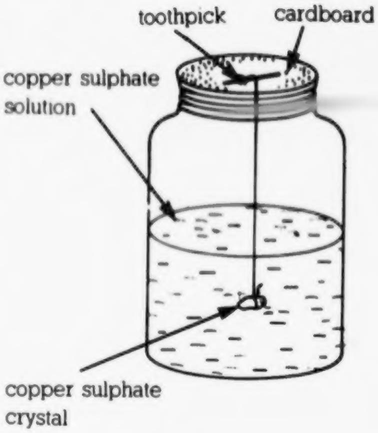
4 Gently heat your saturated solution of copper sulphate until all the copper sulphate is dissolved.

5 Let the solution cool to room temperature.

6 Make sure that your hands are clean for this next step. While your solution is cooling, choose a large, nicely shaped copper sulphate crystal. Carefully tie the cotton thread around it.

7 Cut the cardboard into a circle that will just fit on top of your jar. Make a small hold in the centre to put the thread through.

8 Pour the cooled solution into the jar and suspend your crystal in it, about 3 cm from the bottom, as shown in the diagram.



9 Screw on the lid, label the jar, and put it in a safe place for at least a day.

Crystals usually grow better if the temperature is kept fairly steady. One way of doing this is to put your jar in an ice-cream container of water.

10 Carefully take your crystal out of the jar. Do not touch the crystal with your fingers.

11 Dry the crystal with tissue paper and look at it. Use a hand lens to examine it more closely. What can you see? Make a drawing in your notebook.

12 You can keep growing your crystal by making a fresh solution of copper sulphate, following Steps 1 to 5, and suspending your crystal in it again.

13 Try growing other crystals using chrome alum or potash alum.

FURTHER ACTIVITIES

1 Work out how much water is used each day in your home. Write up a report describing exactly how the water is used.

Would the amount of water used ever vary? Why?

2 Each day you lose about 3 litres of water from your body. The following table describes how water is lost.

Breathing out	400–500 mL
Sweating	600–900 mL
Urinating	1500–1900 mL

(a) What things may influence the amount of water lost in each of these ways?

(b) What other substances are lost when water is lost in each case?

(c) Where does the replacement water come from?

SUMMARY

- **Water has a boiling point of 100°C.**
- **When water boils, steam is produced by a process called evaporation.**
- **Steam can be condensed on a cold surface so that water is formed.**
- **When vegetables are cooked using a steamer they are tastier and more nutritious.**
- **Water and oil have different boiling points and different ways of flowing.**
- **Salt can lower the freezing point of ice.**
- **Some substances are more soluble than others in water.**
- **The solubility of substances which dissolve in water increases with increasing temperature.**
- **You can get the particles in a solution to bind together to make crystals.**

REVISION QUESTIONS

1 How do the experiments you have done in this chapter help to explain how clouds are formed?

2 Explain what these terms mean: solvent, solute, solution, dissolve.

3 Four groups of students measured the temperature of ice. They recorded the following results:

Group 1	1°C
Group 2	1.5°C
Group 3	0.5°C
Group 4	0.0°C

(a) Why might the results be different?

(b) Work out the average result.

(c) What would happen if you added salt to the ice?

(d) Explain why you think people put antifreeze in their car radiators when they drive up to the snow.

WATER LEVEL IS FINE.... COULD BE SOFTER, THOUGH...

4 100 mL of oil and 100 mL of water were each poured through identical filter funnels and collected in a clean beaker. The following results were obtained.

	Liquid A	**Liquid B**
Time to be collected	61 seconds	25 seconds

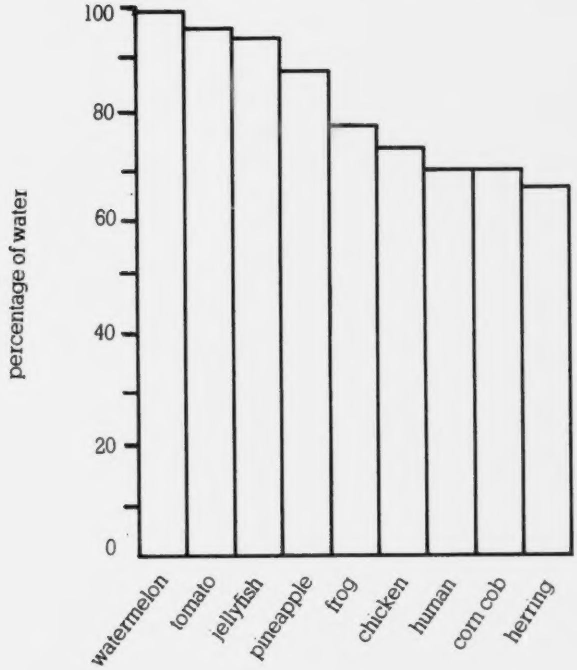
(a) Is Liquid A oil or water? Explain your answer.

In a second test by another group of students the following results were recorded.

	Liquid A	**Liquid B**
Time to be collected	55 seconds	20 seconds

(b) What are some possible explanations for the difference in the results of the two tests?

5 The following graph shows the amount of water found in some animals and plants. The amount of water in each has been expressed as a percentage.



(a) Which organism contains the highest percentage of water?

(b) Which organism contains the lowest percentage of water?

(c) If you were very thirsty and there was nothing to drink, which two of the above would provide you with the most water?

6 PLANTS AND SOILS

Have you done any gardening lately? Did you notice how the soil can vary in colour and texture? When we take time to look at it closely, we find that soil is quite complex. Some plants grow well in some types of soil and not so well in others. In order to help us understand more about how soils help plants to grow we need to understand more about what a plant needs for growth.

In this chapter you will be observing plants growing. As plants take a while to grow, you may find it a good idea to study another chapter at the same time as this one.

This chapter should help you answer the following questions:

- What do plants need in order to grow?
- What makes up soil?
- What makes a good soil?
- What is humus? Where does it come from? Why is it important?
- What is the structure of a plant?
- What do we find in seeds and flowers?
- What role do chemicals play in the soil?
- Why will plants grow in some soils and not in others?
- How do you make good compost?

PLANT REQUIREMENTS

To understand something about how soils contribute to plant growth we first need to understand a little more about plants. When doing experiments involving growing plants you have to be patient. You also have to think ahead – in other words set up an experiment now if you want to see the results in a week's time.

ACTIVITY 1

How do plants depend on soil?

Work in groups of three or four for this activity.

Steps to Take:

1 Write down your ideas about the following questions:
   (a) What do plants need in order to grow?
   (b) How do soils contribute to plant growth?

2 Discuss your ideas with others in your group. Write down any further ideas that have come out of your discussion.

Before we investigate what plants need to grow, let us first look at the seed from which a plant grows.

ACTIVITY 2

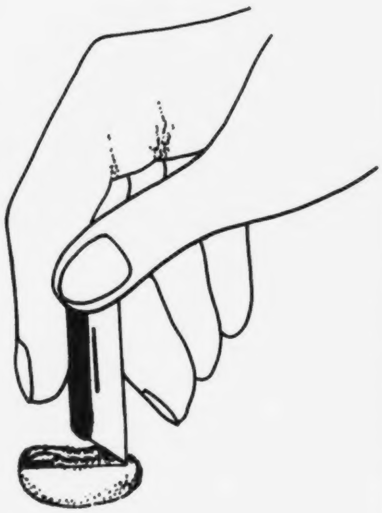
What's in a seed?

You Will Need:

- Three seeds which have been soaked in water for at least 24 hours (a French bean is suitable because it is fairly large)
- A scalpel or razor blade (preferably with a single edge)
- A jar
- Blotting paper
- A hand lens or stereo microscope

Steps to Take:

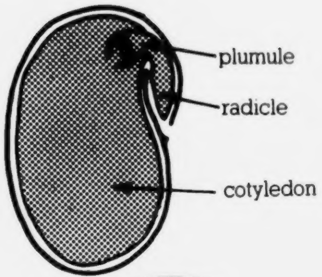
1 Cut open the seed from top to bottom as shown in the diagram.



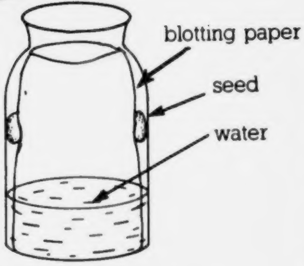
Safety! Take care with the scalpel or razor blade.

Seeds are like small plants. Use the diagram to help you to identify the radicle. The **radicle** will grow into the root of the seedling.

Look for the **plumule**. The plumule will grow into the shoot of the seedling. The **cotyledons** are the seed leaves in which food may be stored for the growing seedling.

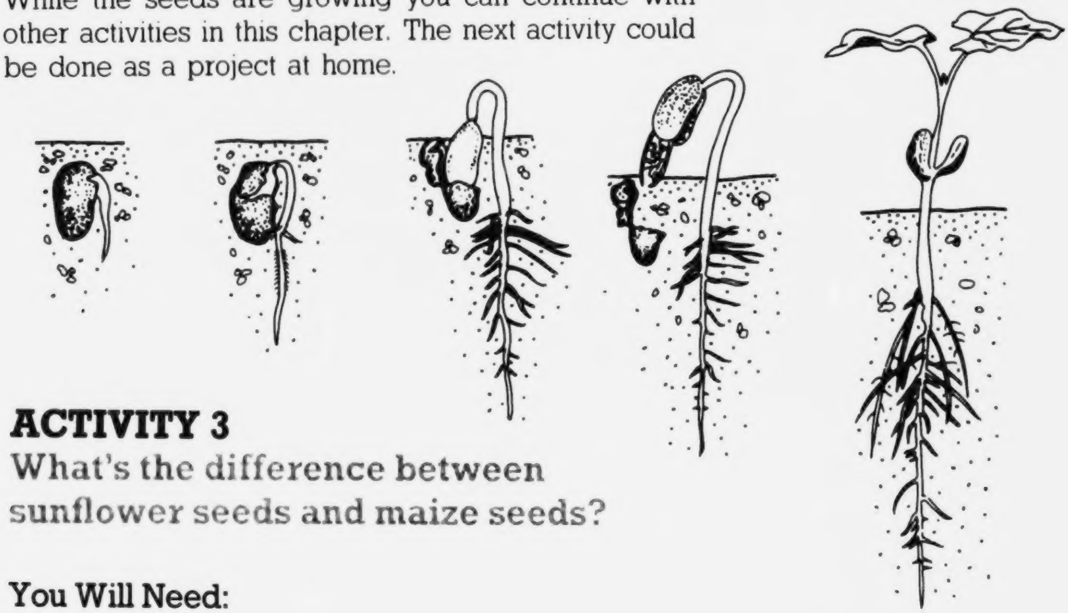


2 Put some blotting paper in a dry jar. Push the remaining two seeds as shown in the diagram between the paper and the jar. Pour water into the jar to about a depth of 3 cm.



3 Observe the seeds carefully each day (if possible) and make careful drawings to illustrate developments.

While the seeds are growing you can continue with other activities in this chapter. The next activity could be done as a project at home.



ACTIVITY 3

What's the difference between sunflower seeds and maize seeds?

You Will Need:

- Some sunflower and maize seeds which have been soaked overnight.

Steps to Take:

1 Examine the soaked sunflower and maize seeds as you did when you looked closely at the seeds in the last experiment.

How many seed leaves (cotyledons) does each seed have?

Do the seeds have any special food store?

2 Set up a jar with blotting paper, as in step 2 of Activity 2. Compare how the seeds grow.

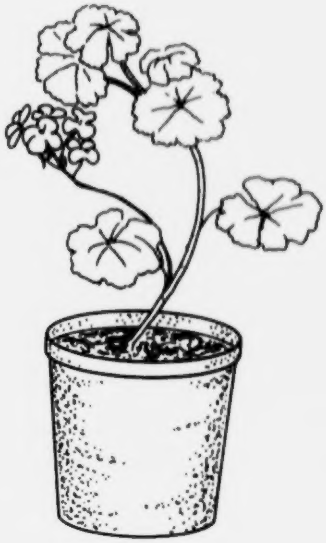
3 Make some drawings of your observations.

4 Compare your findings with others.

The seeds grow into fully-developed plants. In the next activity let's look at the main parts of a fully grown flowering plant.

ACTIVITY 4

What's the structure of a flowering plant?



The main parts of flowering plants are the flower, the seed, the fruit, the leaf, the stem and the root.

You Will Need:

- Any fully grown plant with flowers and seeds, if possible (for example, sweet pea, mustard, wall-flower, geranuim, lupin, strawberry)
- A hand lens and a stereo microscope
- A scalpel

Steps to Take:

Investigate each of the parts of the plant in turn.

1 **Stem**
- What is the colour of the stem?
- Does the stem have any ridges?
- Is its surface smooth or hairy?
- Does the stem have any buds?
- What else can you observe?
- Why do you think plants have stems?
- Think about what would happen if the plant had no stem.

2 **Leaf**
- What are the shape(s) of the leaves?
- What colour are they?
- Do the leaves have any veins? If so, draw a detailed pattern of the veins.

- Write down what you think the veins are for.
- What do the leaves feel like? Are there any hairs on their surfaces?
- Crush one of the leaves between your thumb and fingers. Record any smell you detect.
- What do you think leaves are for?

3 Root

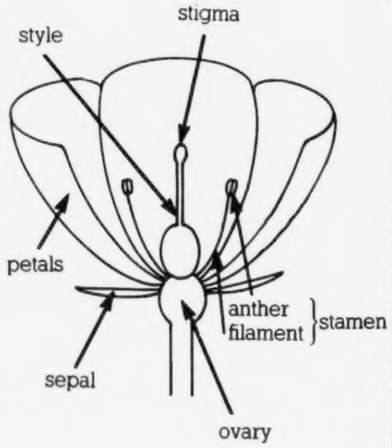
- Describe what the root looks like.
- Write down what you think roots are for?

(We will be look in more detail at the root in the following activities.)

4 Flower

Flowers are made up of lots of different parts. Try to find these parts on your flower. You might have to cut your flower in half to find some of them.

- The **sepals** are the small green leaves at the base of the flower.
- The **petals** are usually the coloured parts next to the sepals.
- The **stamens** are found inside the petals. They look like white stalks with yellow pollen sacs on the top.
- The yellow pollen sacs on the stamens are called **anthers**, and the white stalks are called **filaments**.
- At the centre of the flower is the **style** (or styles). It looks like a white stalk too but it is different from the stamens. It has a small sticky top and a swollen base.
- The sticky top of the style is called a **stigma**.
- The swollen base of the style is called the **ovary**.
- If you carefully cut the **ovary** in half you will find the **ovules**.
- As you investigate each part of the flower, try to work out what it might be for.
- Although flowers all follow the same basic plan, they aren't all exactly like the one in the diagram. Compare the different flowers you have investigated.



5 Fruit

When the ovary wall swells as it matures, it becomes a fruit. The ovules become seeds.

- Look at the older part of the plant to see what the fruit looks like.
- Write down any ideas about the way the seeds inside might be spread around.
- Draw the seeds.

6 Discuss your answers with a partner.

The root has many functions. It keeps the plant fixed in the soil and it also absorbs water and soluble mineral salts from the soil. Sometimes the root stores food for the plant. Let's find out more about the root.

ACTIVITY 5

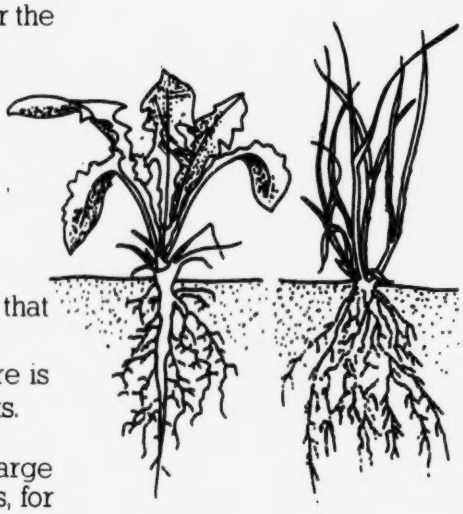
What's the difference between tap roots and fibrous roots?

There are two types of root systems:

(a) the **tap** root – this has one main centre root that grows downwards.

(b) the **fibrous** root. In this type of root system there is no one major root, but a lot of branching roots.

In some cases tap roots are used to store large amounts of food that the plant has made in its leaves, for example, carrots and turnips.



Tap root. Fibrous root.

You Will Need:

- A range of root systems and examples of food storage in roots. (Your teacher will need to collect these examples for you so that you can share them around. This will save unnecessary damage to plants. The roots will need to have the soil carefully washed from them so that they are not damaged.)
- A hand lens and a stereo microscope

Steps to Take:

Examine the various root systems. Draw an example of a tap root system and a fibrous root system in your notebook.

- What features do the two root systems have in common?
- Is food stored in both root systems?

Plant roots spread out in the soil to cover a large area. To make that area even larger, each root is covered in small hairs.

ACTIVITY 6

What do root hairs do?

You Will Need:

- A glass dish
- Cotton wool
- Presoaked wheat seeds
- A magnifying glass
- A microscope or stereo microscope

Steps to Take:

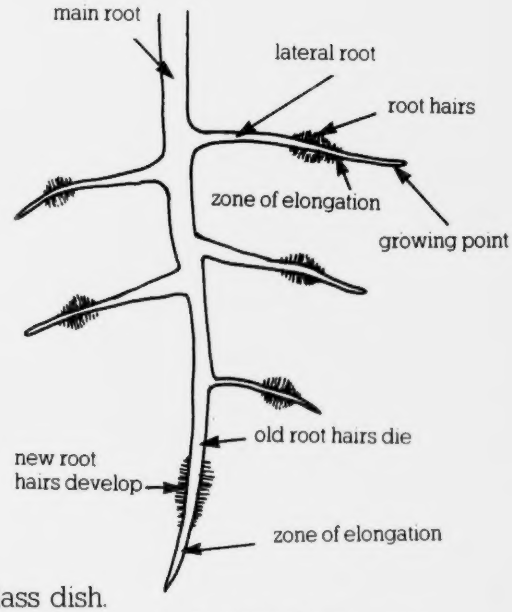
1 Soak the cotton wool and place it on the glass dish. Put 10 wheat seeds on the cotton wool. (The wheat seeds should be soaked for at least 24 hours beforehand.) Then cover the dish or put it in a dark cupboard. In two to three days the seeds should have **germinated**.

2 Examine the seeds with a magnifying glass. Draw a picture of a root with root hairs. Are there hairs right at the tip of the root?

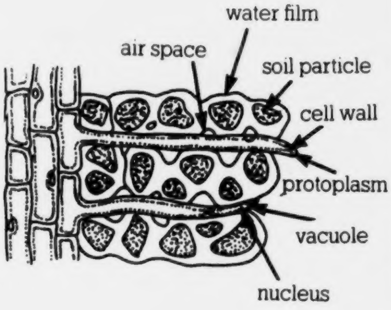
3 Examine the root hairs under a microscope. Draw one.

Root hairs are large cells. In fact they are some of the largest cells you can find. The root hairs act like thousands of tiny arms reaching into the soil for water and soluble salts. So instead of having the surface of just one root, the root hairs enable the root to feed from a much larger area.

We know that plants absorb water and soluble substances from the soil. Let's now look at how they do that.


main root
lateral root
root hairs
zone of elongation
growing point
old root hairs die
new root hairs develop
zone of elongation

Regions of a root system.


water film
air space
soil particle
cell wall
protoplasm
vacuole
nucleus

Root hairs in the soil.

EXPERIMENT 1

How do roots absorb water?

One way we can check that plants absorb water is by putting a plant into some water with a dye.

You Will Need:

- Some small seedlings, or weeds collected from the schoolground.
- Food dye (or other water soluble dye)
- A small specimen tube (or small jar or beaker)
- A scalpel or razor blade

Steps to Take:

1. Put one seedling into the specimen tube. Add some food dye and water to the tube.
2. After the seedling has been in the coloured water for half an hour, take it out.
3. Cut across the root just behind the root hair region as shown in the diagram. Can you see any dye there? Can you see the dye in any particular areas? Describe how you account for your observations.
4. Compare your ideas with others.
5. Find out what would happen if you left the seedling in the dye for longer. See if the dye goes to other parts of the plant. Explain your findings.

In the next activity we can look at some common vegetables we eat and consider what part of a plant they each are.

ACTIVITY 7

What are the vegetables we eat?

You Will Need:

- A range of vegetables (celery, potato, tomato, carrot, pea, bean, zuchini, egg plant, onion, cabbage, etc.)
- A scalpel or a razor blade with a single edge

Safety! Be very careful when using scalpels and razor blades.

Steps to Take:

1 Write down the name of the vegetable in your notebook and which part of the plant you think each vegetable is. You will need to slice each vegetable to check what is inside.

2 Check your findings and ideas.

In the next experiment we can look at what conditions are necessary for seeds to grow.

EXPERIMENT 2

What conditions are necessary for seeds to grow?

We know that when there is a drought crops do not grow. We also know that few plants grow in very cold areas. So we could check out whether plants need water and warmth for growth. We can also check whether seeds need air and light. We might expect that they do need air so that they can respire. But do they need light?

We need to set up an experiment to test what sorts of conditions plants need to begin growing. If we set this experiment up now, we can watch the plants grow and take note of any changes as we work on this topic.

You Will Need:

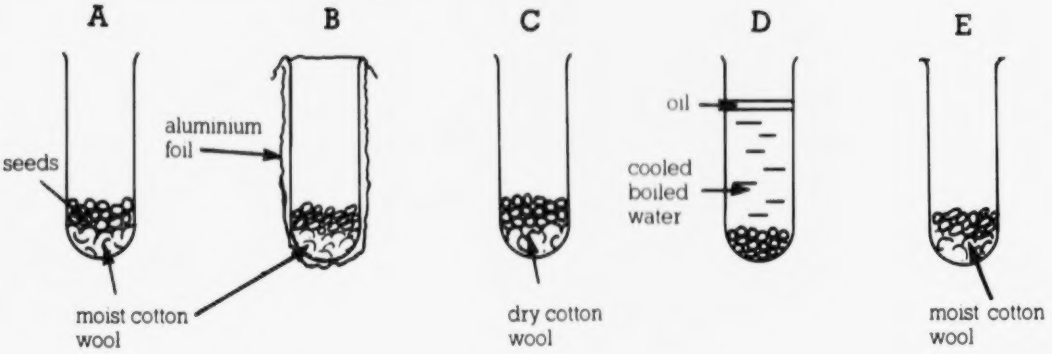
- Five boiling tubes (or vials)
- Some cotton wool
- Presoaked seeds (e.g. mustard, cress or peas)
- Aluminium foil
- Texta pen
- Plastic wrap
- Oil

Steps to Take:

1 Write down any what you think a seed might need to begin to grow. For example, does it have to have warmth, light, air and moisture? This is your hypothesis.

2 Clean the tubes thoroughly.

3 Set up the tubes with the following conditions. Use aluminium foil to keep out the light and put tube E in the refrigerator to keep it cold.


A
B
C
D
E
seeds
aluminium foil
moist cotton wool
dry cotton wool
oil
cooled boiled water
moist cotton wool

A	B	C	D	E
air	air	air	no air	air
moisture	moisture	no moisture	moisture	moisture
warmth	warmth	warmth	warmth	cold
light	no light	light	light	no light

4 Place all the tubes, except tube E, together on a window sill and leave them for a few days – a week is ideal. Meanwhile continue working through this chapter.

5 Draw up a table and record your observations. You could use a table like the one below.

Date	Tube A	Tube B	Tube C	Tube D	Tube E

6 Continue your observations for another week or two if possible.

7 Check that your observations agree with those of other groups. Try to account for any differences.

8 (a) Which seeds started to grow?

(b) Did the seeds in the dark grow? What did they look like compared with the seeds grown in the light?

(c) Which of your hypotheses are correct?

(d) What do you think the experiment showed about why the seeds started to grow?

9 (a) From this experiment, what does soil have to do with plant growth?

(b) What part of plant growth is not influenced by soil?

10 Did you consider any other hypotheses? How could you test for these?

11 Discuss your answers with others in the group.

In Experiment 2 you saw that seeds need water, warmth and air to germinate. They didn't need light. This is because seeds use their own food store. Once the seeds have germinated the seedlings will need light so that they can make their own food.

In the next activity you can take a closer look at what plants may need from the soil. We will do this by comparing how plants grow in distilled water – that is with no mineral salts – with how they grow in solutions containing different mineral salts.

EXPERIMENT 3

Do plants need mineral salts?

This activity will take a few weeks to complete. Work in groups of four.

You Will Need:

- Four plant pots
- Builder's sand
- 40 wheat seeds
- Four bottles of different plant food solutions.

No. 1 will contain distilled water which has **no mineral salts**.

No. 2 will contain all the plants' mineral requirements – **all mineral salts**.

No. 3 will have no nitrogen – **mineral salts minus nitrogen.**

No. 4 will have no phosphorus – **mineral salts minus phosphorus**.

Steps to Take:

1 Plant 10 wheat seeds in each pot and water lightly with distilled water. Keep the soil just slightly damp. When the plants are about 5 cm tall, weed out the five smallest plants in each pot.

2 From then on, each week, each pot should receive 100 mL of its food solution. If necessary, add just enough distilled water to keep the soil damp. Be careful not to make the soil too wet.

3 Make up a table, like the one below, in which you can summarise your results. When you are thinking of headings for the table, work out what you are looking for, e.g. number of leaves, height of plants, colour of leaves, etc.

Each week write down:

(a) how tall your plants are (check that you have a way of measuring them all the same way)

(b) the colour of the leaves, their size and any markings

(c) the number of leaves.

Date	Features observed	**Solutions**			
		1. No mineral salts	2. All mineral salts	3. No nitrogen	4. No phosphorus
	Height of plants Number of leaves Size of leaves Colour of leaves Markings on leaves Other				
	Height of plants				

5 Record what you have learned about plants and mineral salts. Did your results agree with your predictions?

In this section you have examined the structure of seeds and the conditions required for their growth. You have investigated the structure of fully grown plants and considered, in particular, the roots and root hairs that enable them to use the soil for healthy growth.

SOIL

ACTIVITY 8

What is soil?

To find out what soil is, we must look at it closely. To do this we will look at the soil with a magnifying lens and see how many different things we can identify.

You Will Need:

- Half a cup of soil
- Two pieces of paper, A4 size
- A hand lens and, if possible, a stereo microscope
- A pencil

Steps to Take:

1 Look at your soil with a hand lens. Can you see different things in the soil? Now have a look with stereo microscope. What else can you see?

2 Separate your soil into different piles of the different sorts of things you see. Use a pencil or finger. How you separate your soil will depend on the sort of soil you have. The types of piles you could make are:

(a) living things only (plants and animals)

(b) non-living things only (parts of animals, leaves, twigs, etc.)

(c) mineral matter (fine gravel, sand, silt and clay).

3 Describe what sorts of piles you divided your soil into and what was in each pile. Make sure you write down the feel, smell and look of each pile.

ACTIVITY 9

What is in the soil?

You Will Need:

- A tall measuring cylinder
- A hand lens

Steps to Take:

1 Half fill the measuring cylinder with soil.

2 Add water almost to the top of the cylinder. Shake the cylinder well with your hands over the top and bottom.

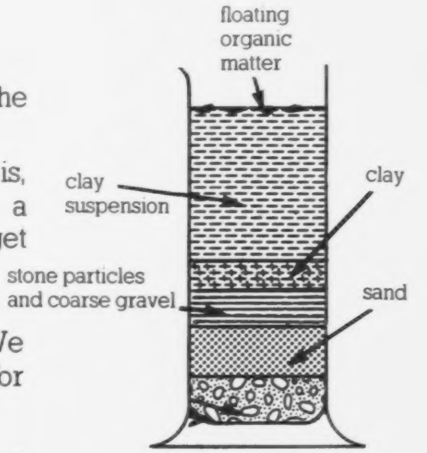
3 Place the cylinder on the bench and watch the soil settle.

(a) What parts of the soil settle first?

(b) What parts settle last?

(c) What do you think size has to do with the way the particles settle in the cylinder?

(d) Is there anything floating on the top? If there is, carefully remove it and examine it with a hand lens. What can you see and how did it get there?



An example of a soil column. The layers will vary in thickness according to your soil sample.

The different parts of the soil separated into layers. We will call this a soil column. Save your soil column for other work.

As you will have seen in Activity 8, soil particles come in different sizes. Soil grains are divided into four types, named by their size.

(a) **fine gravel** (the largest)
(b) **sand**
(c) **silt**
(d) **clay** (the smallest)

Look at your soil column from Activity 9. Did you have any clay, silt or sand? Write down what you had and draw a labelled diagram of your soil column.

Sand

What do you think sand is? Sand is made from large mineral particles. Beach sand may include broken pieces of shell and coral.

Sand has a gritty feel. This is described as its **texture**. If you take a handful of sand, you will notice that the particles do not stick together, unless you wet them. Once they dry though, the particles fall apart.

Silt

Silt is different from sand in two ways:

(a) it has smaller particles

(b) it has a silky, not a gritty, texture.

Although silt is different from sand in these ways, it is not sticky. Even when silt is wet the particles doesn't stick together very well.

Clay

Clay is different from both silt and sand in that it is made up of *very, very* tiny particles.

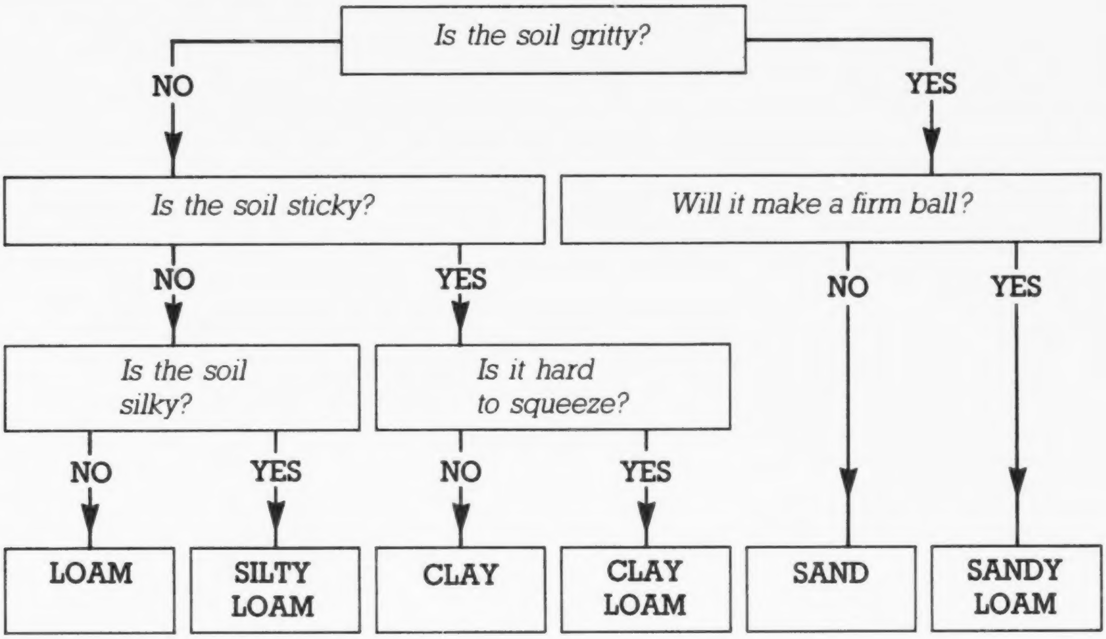
When clay is wet the particles cling together. This gives clay a sticky texture and makes it feel a bit like plasticine. When it dries, it is quite hard. It breaks up into lumps.

As clay is sticky, it is good for making things like pots and sculptures. If it is dried properly, it will make a hard structure.

Sand, silt and clay do not make good soils on their own. Sand is not a good soil because it is too coarse and it doesn't stick together. This means it doesn't hold plant roots very well. Silt is a little similar because it doesn't stick together either. Clav is not a good soil because it is too fine and it becomes very hard when dry which makes it difficult for plant roots to grow.

Most soils are a **mixture** of sand, silt and clay. They are called **loams**. Loams are the best soils for growing plants. In different places, different types of loams are found. Some are sandy loams that have more sand than silt or clay in them. Clay loams have more clay than sand or silt in them.

The flowchart below shows how soils are named. The name of the soil depends on how much sand, silt and clay it contains. By feeling the texture of a soil it is possible to work out if it has a lot of sand, silt or clay.


Is the soil gritty?
NO
YES
Is the soil sticky?
Will it make a firm ball?
NO
YES
NO
YES
Is the soil silky?
Is it hard to squeeze?
NO
YES
NO
YES
LOAM
SILTY LOAM
CLAY
CLAY LOAM
SAND
SANDY LOAM

ACTIVITY 10

What type of soil?

You Will Need:

- Your cylinder of soil from Activity 9
- Some samples of different soils

Steps to Take:

1 Write down what you think makes a good soil.

2 Re-examine your soil column. Can you tell what type of soil you might have by just looking at it? Why?

3 Take a handful of soil from one of the samples and use the soil flowchart to decide what type of soil you have.

4 Check the soil in your backyard at home. What type of soil is it?

What makes a good soil?

So far we have seen that a soil needs to be a mixture of silt, clay and sand. These loams are the best for growing plants. But there are other important requirements for a good soil. For example, we saw in Experiment 3 that plants need mineral salts.

Like us, plants need oxygen. This means that if there isn't any **air** in the soil, the plant roots will die. We can work out how much air there is in the soil by doing the following experiment.

EXPERIMENT 4

How much air is there in the soil?

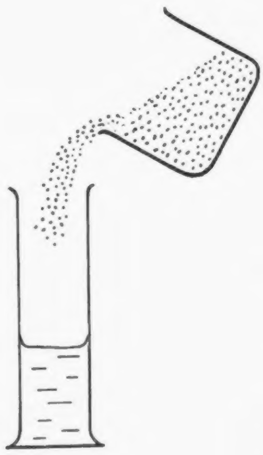
You Will Need:

- A plastic cup — about 100 mL
- A ruler
- A 250 mL measuring cylinder
- Soil

Steps to Take:

1 Fill the plastic cup with soil, taking care not to press in the soil too hard. Then, using the ruler, scrape the surface of the cup so it is level.

2 Put 100 mL of water into the measuring cylinder and then add the soil. Tap the cylinder gently on the bench to shake out the bubbles. Record how much volume the soil and 100 mL of water occupy.



3 Tip the soil and water out into a bucket (not the sink!) and using the measuring cylinder, work out how much water it takes to fill your plastic cup.

4 (a) What volume of soil did you add to 100 mL of water?

(b) What was the total volume of the shaken water and soil?

(c) How much of your soil sample was really air?

(d) Did you notice anything happen when you tapped the cylinder on the bench?

5 Discuss your answers with a partner.

One very important part of soil we have not yet mentioned is **water**.

EXPERIMENT 5

How much water does soil hold?

Work in groups of three or four.

PART 1

You Will Need:

- Soil
- A balance
- A tin (a small baby food tin would be ideal)
- A label

Steps to Take:

1 Measure the mass of your tin and record it.

2 Put some soil in the tin – enough to at least completely cover the bottom, probably about a teaspoon of soil.

3 Measure the mass of the tin containing the soil and record it.

Mass of tin	
Mass of soil and tin	
Mass of soil	

4 Now, label the tin with your name. Place the soil sample aside for two days and allow it to air dry.

5 At the end of the two days, reweigh your soil and tin. Record the result. Calculate how much mass your soil has lost.

Mass of soil and tin after 2 days	
Mass of soil after 2 days	
Lost mass of soil	

6 Write down what is responsible for this loss of mass.

PART 2

You Will Need:

- Your soil sample from Part 1
- A balance
- A tripod
- Wire matting
- A Bunsen burner

Steps to Take:

1 Place your tin containing the air-dried soil on the tripod and gently heat it until you can see some water vapour (steam) leaving the soil. Heat it like this for about five minutes.

2 Turn off the Bunsen burner.

3 Wait for the tin to cool down, then weigh it and the contents.
What is the loss of mass this time?

4 Calculate how much mass has been lost from your original soil sample. To do this, add the loss of mass from Part 1 to the loss mass for Part 2.
Why you think this loss of mass has occurred?

The effect of humus on soil

As we found out in Activity 9, soils are not made up of just mineral particles; they also contain animals and plants and their remains. Soils also contain dissolved substances.

When a layer of plant litter (parts of dead plants, leaves, etc.) builds up, it is decayed by bacteria and mould to form **humus**. Humus contains small particles of decayed animal and plant remains.

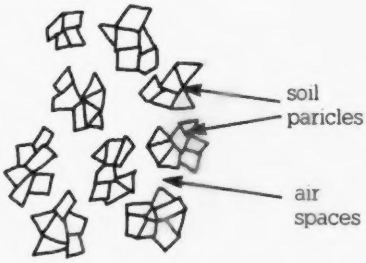
Humus is very important to the soil because it acts a bit like glue and helps the soil particles stick together in crumbs.

This has the effect of allowing more air space in the soil because the soil particles stuck together in small crumbs don't pack down so well.

Humus is also a rich source of plant chemicals which encourage plant growth.

Humus gives the soil its grey or black colour. If you look at a place where the soil has not been disturbed, you may notice that there is a layer of darker topsoil.

This soil contains humus and is a good soil for growing plants in. The soil around river flats is usually dark because it contains lots of humus.



Soil crumbs.

Animals in the soil

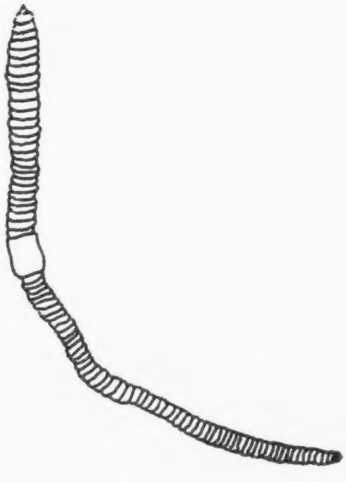
There are many animals of varying types and sizes found in the soil. Let's look at one of the important ones, the earthworm.

EXPERIMENT 6

Why are earthworms important?

You Will Need:

- A glass sheet
- An earthworm
- A jar filled with moist garden soil
- A sheet of stiff brown paper, 20 cm × 20 cm
- A hand lens



Steps to Take:

You looked at movement in earthworms earlier (see page 47). Let's see if your observation is improving before you get on to the second part of the activity.

1 Look at the earthworm with a hand lens. Can you see any little bristles?

2 Put the earthworm on to some brown paper. Describe how it moves. Describe what you can hear. How do you account for this?

3 Transfer the earthworm to the sheet of glass. Again listen to see if you can hear anything.

4 Put the earthworm into the jar of soil. Add a few dead leaves to the top of the soil. Leave the jar for a few days, checking it every day. What happens to the leaves? Record your observations.

5 From what you have learnt about earthworms, write a short report explaining why earthworms are important to us.

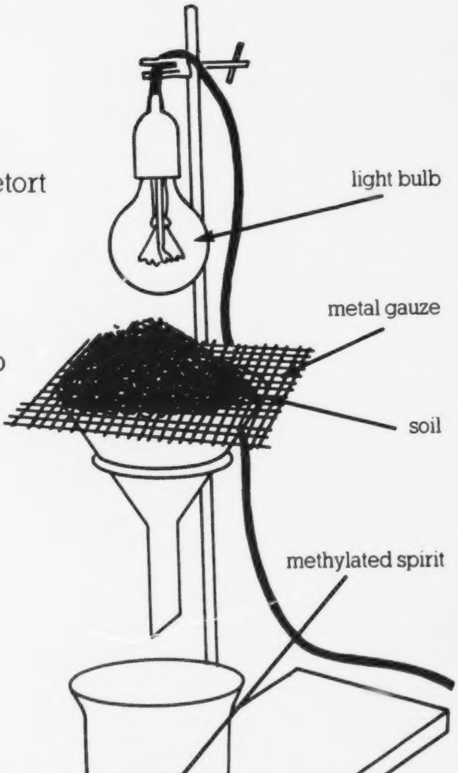
Now let's find out if there are other animals in the soil. Here is a chance for you to test your skills of observation using a microscope. You may have to do the first part of this activity in groups depending on the availability of the apparatus or your teacher might do the experiment as a demonstration.

EXPERIMENT 7

What else lives in soil?

You Will Need:

- A retort stand
- A 40 watt light bulb on a lead attached to the retort stand by a clamp
- A large filter funnel
- A piece of wire gauze
- A ring attached to the retort stand by a clamp
- Black paper to wrap around the funnel
- Some adhesive tape
- A beaker containing 3 cm methylated spirit
- A handful of topsoil
- A hand lens
- A stereo microscope



Steps to Take:

1 Write down what effect you think the heat and light from the globe will have on the soil and soil animals.

2 Put the topsoil on to the wire gauze and leave for half an hour.

3 Put the beaker of methylated spirit under the funnel to catch any animals which fall. The methylated spirit will kill and preserve them.

4 Switch on the light. Leave the light switched on for at least one day.

5 Use a hand lens and stereo microscope to help you investigate the animals.

We have been learning more about soils so that we can understand more about plant growth. We know that seeds will grow in soil, but what will happen if we just cut off some bits of plants and put them in the soil? Do you think they will grow? Let's try.

ACTIVITY 11

Can you strike some plant cuttings?

You Will Need:

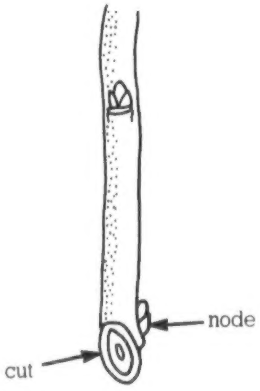
- Geranium, fuchsia or carnation plants (nearly any time of the year)
- A scalpel or razor blade

Steps to Take:

1 Take the plant and, using the scalpel, cut off the end of a branch just below two leaves. The point where the leaves are attached is called a **node**.
The best time to do this is in the early morning after watering the night before. Why would this be so?

2 Make up some striking mixture from:
- Three equal parts of clean sand or vermiculite
- One equal part of mashed-up peat moss or leaf mould.

3 Fill pots or trays with the striking mixture. Take a pencil (or a similar shaped instrument) and make holes for each of the cuttings, deep enough to insert half their lengths. You can put several cuttings in one pot.



4 Put the cuttings in the holes. Pinch the soil around the base of the cuttings. Don't let the soil dry out.

5 After six weeks, gently dig out the seedlings. If you can see that roots have developed, put the cuttings into their own pots.

6 Try striking cuttings from other plants. Which work best?

We have seen that soil is complex. It can contain fine gravel, sand, silt, clay, humus, air, mineral salts, water, and live animals and plants. We can classify a soil according to its texture, which depends on how much silt, sand or clay it contains. The different parts of the soil contribute to the growth of plants. You have had the opportunity of using soil to strike some cuttings.

MORE DIFFERENCES IN THE SOIL

Good soils enable plants to grow well. A plant requires water, air, minerals and humus. The humus has a very special role because as well as increasing the air spaces in the soil, it also adds special substances to the soil. Some of these substances are essential plant food. Plants won't grow without them.

Nitrogen is one of the substances needed for healthy plant growth. Nitrogen in the soil is commonly found in two salts, sodium nitrate and ammonium sulphate. Let's find out how soluble these salts are.

EXPERIMENT 8

How soluble are sodium nitrate and ammonium sulphate?

You Will Need:

- Two test-tubes
- Sodium nitrate
- Ammonium sulphate
- A spatula
- A test-tube rack

Steps to Take:

1 Into one test-tube place a spatula of sodium nitrate. Add enough water to cover the solid to three times its depth. Shake the tube gently.

2 Repeat Step 1 for ammonium sulphate.

3 Describe what happens to your two salts.

The salts disappear or dissolve. This means they are soluble. Very soluble substances dissolve easily.

4 Discuss the question "Can plants get nitrogen from the soil if it contains sodium nitrate or ammonium sulphate?"

Sodium nitrate and ammonium sulphate, contain **nitrogen**. As we have seen, both of these substances are soluble. This means that roots can absorb the nitrogen in them, but it also means they are washed out of the soil easily.

So, when it rains or you water the garden, you are sometimes not only adding valuable water, but also washing away valuable nitrogen. However, there are two ways of putting nitrogen into the soil:

animal waste products.

(b) Lightning helps put nitrogen into the soil. The lightning makes nitrogen gas in the air combine with other gases and they fall to the ground and form nitrates.

When plants rot away, the nitrogen in their cells is taken up by the roots of other plants. In this way the nitrogen is used over and over again. This is called the **nitrogen cycle**. This cycle is quite complicated and we will look at it more closely in a later book.

Plants, if left untouched, remain in this cycle. But plants grown for food, like barley and wheat, are harvested and taken away. This means that the amount of nitrogen in the soil will decrease as it isn't being put back via the nitrogen cycle.

Plants need nitrogen to grow. If nitrogen is being lost from the soil, or the soil is poor in nitrogen to begin with we can supply the plants in other ways.

We can use **fertilizers**, either natural or artificial, and we can make **compost**.

Compost is made by heaping up vegetable refuse and garden waste. The refuse and waste decays and forms a type of humus. Like humus it is a black to brown colour.

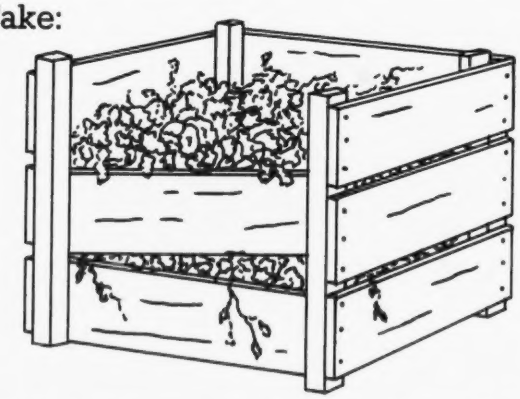
As compost is the product of decay, it needs bacteria in it to cause the decay. Bacteria need both carbon and nitrogen to grow. Compost heaps also need moisture and oxygen. The moisture content should be about 50–55%, so it feels damp but not soggy.

ACTIVITY 12

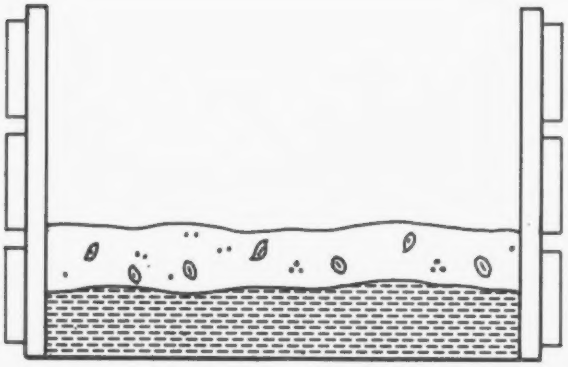
How do you make a compost heap?

You could either work in groups building a compost heap in the school grounds, or, if you have the space, you could make one at home.

Steps to Take:

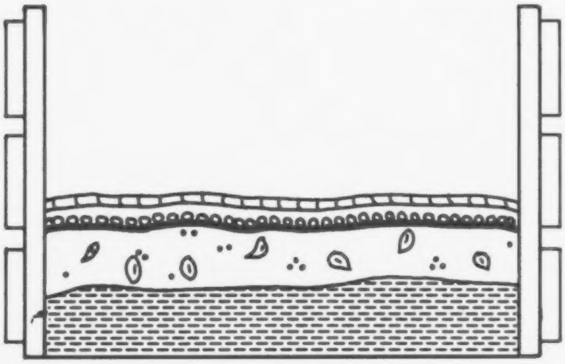


1 Construct a simple compost box as shown in the diagram.



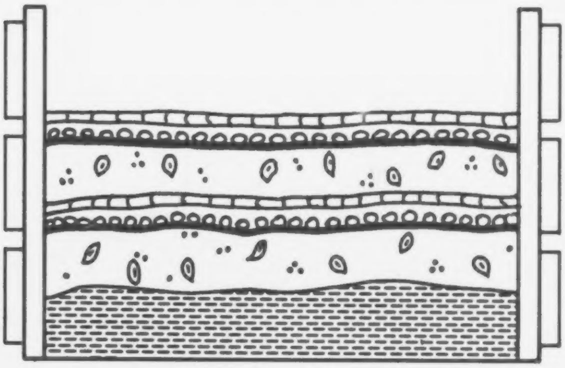
2 If possible, begin with a layer of manure or compost to act as a starter.

3 Add 20 cm of vegetable waste or plant cuttings.



4 Add a thin layer of blood and bone.

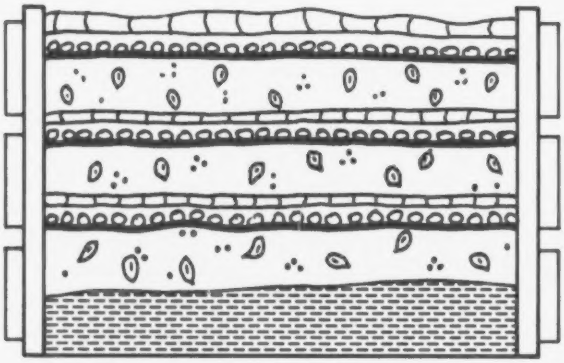
5 Add a thin layer of garden soil.



6 Repeat steps 3–5.

Each layer should be trodden down firmly and lightly watered.

7 Sprinkle garden lime to help the rotting.



8 Poke a stick in the middle to make an air hole. Why?

9 When the box is full put a layer of earth on the top. It should be ready in 3–6 months.

10 Discuss the importance of earth worms in a compost heap.

EXPERIMENT 9

Do fertilizers make any difference?

Your teacher may wish to organise this as a class experiment so that you can look at a range of fertilizers.

You Will Need:

- Small trays or jars of germinating peas in soil
- A sample of fertilizers, for example, Maxicrop, Aquasol, Osmocote, etc.

Steps to Take:

1 Leave one jar or tray without fertilizer – this will be a **control**.

2 Set up one tray or jar of seeds for each of the other fertilizers. Check the instructions on the fertilizer packets.

Remember that you need to keep all the treatments under the same conditions.

3 Work out exactly what you are going to observe. You will have to be precise as there may only be small differences.

Then work out how you are going to record your observations over a period of time.

You have seen that mineral salts containing nitronatural source of nitrogen for plant growth. Artificial fertilizers can also be used to promote plant growth. You can make compost yourself to increase both the humus and the nitrogen content of the soil.

FURTHER ACTIVITIES

1 Compare the effects of growing seedlings in:
  (a) clay, sand, silt and loam
  (b) compact soil, loose soil
  (c) dry, damp and soaked soil.
  Write up a report on your experiment.

2 Investigate soil erosion.

3 Find out about **legumes** and their importance to the soil.

4 Find out about ways of irrigating land.

5 Try growing vegetables at home.

6 Try growing herbs.

7 Find out what a **vivarium** is and make one for the classroom or for your home.

8 Investigate some samples of soil. Do they contain plants? Describe how you go about answering the question and report any conclusions.

9 Find out about how to use potters' clay. Try to make something from it.

10 Find out about **hydroponics**. Design some equipment to test out hydroponics.

11 Collect some seeds from your local area. Try to grow them. You might like to use the plants you grow to improve the school grounds or to provide a resource for local residents.

SUMMARY

- **Seeds are like small plants. They contain one or two cotyledons (seed leaves), a radicle (seed root), and a plumule (seed shoot).**
- **Root hairs make intimate contact with soil particles. They increase the surface area of the root. Their function is to absorb water and soluble mineral salts.**
- **Seeds grow into mature plants which produce more seeds.**
- **Flowering plants have stems, leaves, roots and flowers. The flowers usually comprise petals, sepals, stamens and at least one style.**
- **The vegetables we eat are parts of plants.**
- **Seeds need light, water, air and mineral salts for healthy growth.**
- **Soils can contain sand, silt, clay, humus, air, water, mineral salts and animal and plant life.**
- **Soils can be classified according to their texture.**
- **Earthworms are important animals found in the soil.**
- **Soil supplies nitrogen in mineral salts to plants.**
- **Compost and fertilizers can be used to improve the soil.**

REVISION QUESTIONS

1 Earthworms are found in soil in many areas and they have a very important job as they dig their burrows. What might this job be?

2 How would you find out if a sample of soil had water in it? Write down your ideas.

3 What effect does water have on the following:
(a) sand?
(b) silt?
(c) clay?
(d) loams?

4 Why is air important in soil?

5 How could you find out the amount of air in the soil?

6 What is humus?

7 Why is humus important to the soil?

8 If humus is added to soil, does it improve the soil or not? Why?

9 Where are the fine particles likely to be found in a soil column? Can you suggest why this is?

10 How might irrigation ruin a soil?

11 Could an electrical storm over a paddock be good for the soil? How?

12 Why is nitrogen continually being lost from the soil?

13 Explain what may happen to a farmers' crops if he or she does not use fertilizers.

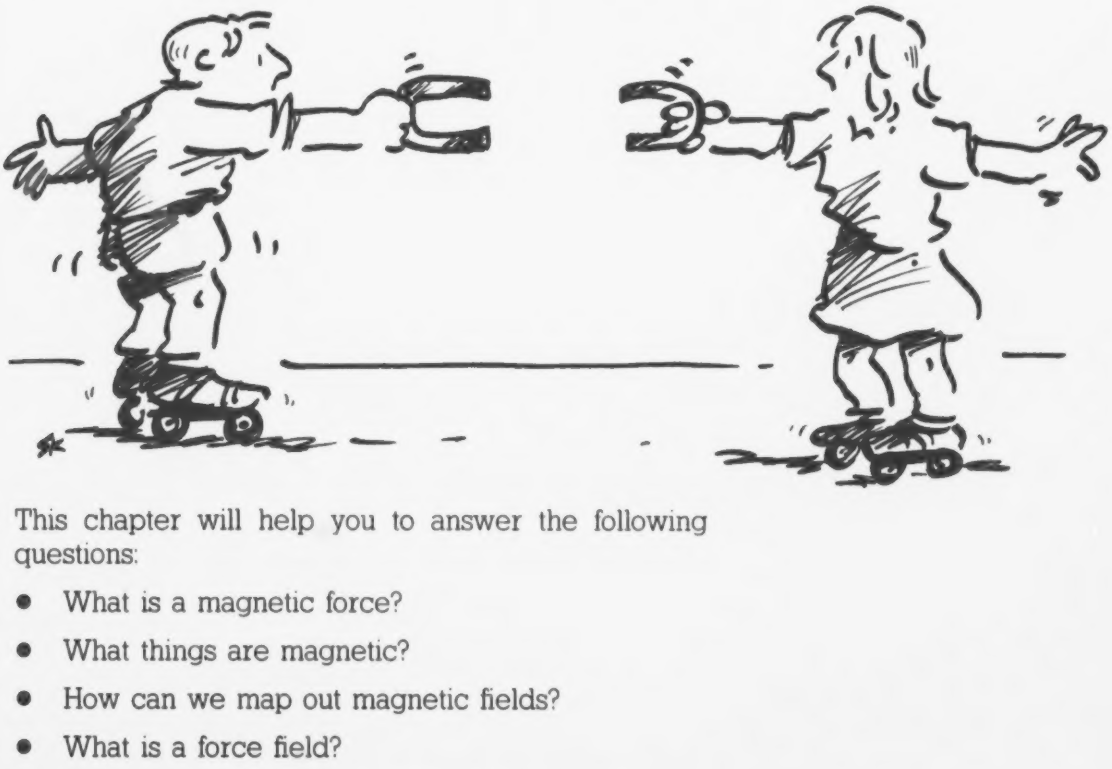
14 Cut a soaked seed in half. Label the parts.

15 Pick a flower from the garden. Can you identify the parts?

16 You are offered two plots of soil in different locations. List things you would need to consider before choosing one for growing a crop of vegetables. Briefly describe some ways you could check each of these.

7 MAGNETISM

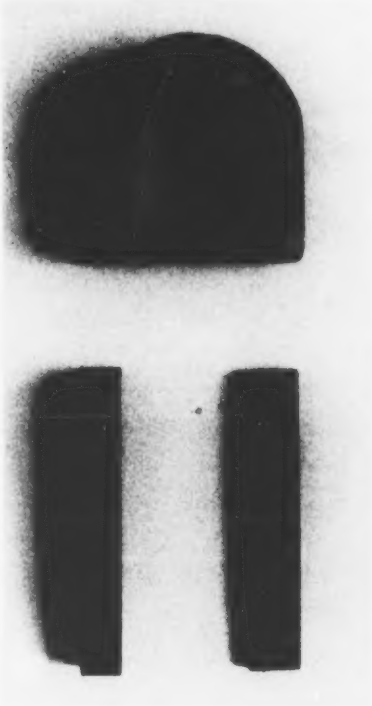
Most of you will at some time have played with magnets. You may also have used a compass to help you find your way. Did you realize that there is a magnet in a compass? And did you also realise that you have used magnetism each time you have used an audio or video casette, or an electric motor?



This chapter will help you to answer the following questions:

- What is a magnetic force?
- What things are magnetic?
- How can we map out magnetic fields?
- What is a force field?
- What are the poles of a magnet and how do they interact?
- What do magnets do to computer discs?

INTRODUCING MAGNETISM



You are probably all familiar with 'horse-shoe' shaped magnets or 'bar' magnets, but magnets come in all shapes and sizes.

Let's find out a bit more about magnets and observe a magnet in action.

EXPERIMENT 1

How does magnetism work?

This experiment will help us to test the following hypotheses (ideas):

- magnetism will work at a distance
- different magnets usually have different strengths.

You Will Need:

- Two bar magnets of different sizes (or strengths)
- A small piece of paper
- A pin
- A ruler

Steps to Take:

1. Place the pin on the desk. Check that the magnet can attract a pin, then separate them so there is no attraction.
2. Bring one end of the magnet gradually closer to the pin.
3. Record how close the magnet has to be before it will pick up the pin. Use a table like the one below.

	Distances between the magnet and the pin		
	Reading 1	Reading 2	Average
Magnet 1			
Magnet 1 plus paper			
Magnet 2			

4 Check your reading again and work out the average distance.

5 Repeat Steps 2 and 4, but this time put a piece of paper between the magnet and the pin. This will help us to test whether the magnetic attraction will go through the paper.

Now try the same steps using a different magnet.

7 Use your table of results to write a conclusion. Remember to check the hypotheses!

Forces are pushes or pulls. From this experiment you can see that magnetism is a force that can act at a distance. This means that a magnet can push or pull something without touching it.

Let's find out more about which materials are attracted by magnets.

EXPERIMENT 2

What sorts of things are magnetic?

In this activity you can classify things into magnetic and non-magnetic materials.

You Will Need:

- A good bar magnet
- Samples of common substances, such as glass, wood, nails, copper wire, aluminium foil, plastic, pins, etc.

Steps to Take:

1 Test each of the materials and record on a table like the one below things that are attracted to the magnet and those that are not.

Magnetic and non-magnetic materials		
Name of material	Magnetic	Non-magnetic
pin	✓	

2 What have you learned?

Magnetic forces affect materials containing of the metals **iron**, **nickel** and **cobalt**. Magnets are made of materials that contain one or more of these metals.

You will probably have used the ends of a bar magnet to attract pins. Magnetism is strongest at the ends of the magnet. We call the ends **poles**.

EXPERIMENT 3

How can you tell which pole is which?

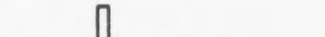
You Will Need:

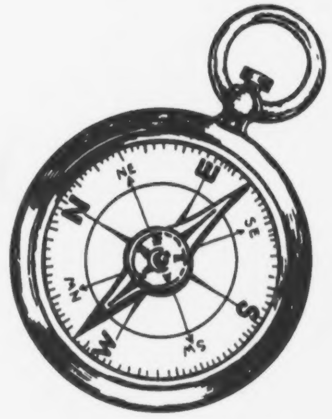
- A bar magnet
- A wooden retort stand and clamp
- Cotton

Steps to Take:

1 Tie a piece of cotton in a double loop around the middle of a bar magnet. Hang it clear of any metal objects. (You may have to use a wooden retort stand and clamp.)

2 If the ends of the magnet aren't already marked to identify them, mark them yourself. (Most magnets have one end painted red, or have N and S stamped at either end.)





3 Notice which way the ends are pointing when the magnet stops moving.

4 Turn the magnet in another direction, then release it and wait for it to stop moving. (The magnet might take a while to stop moving.)

Note what the ends are pointing to. Is it always the same direction for the same end?

5 Now get a compass and find out where north, south, east and west are in your classroom. Make sure you hold the compass clear of the magnet.

6 You can label one end of your magnet as a **north-seeking pole** and the other as a **south-seeking pole**.

The magnets, when allowed, will always point to the north and south magnetic poles of the Earth.

EXPERIMENT 4

How do the poles behave?

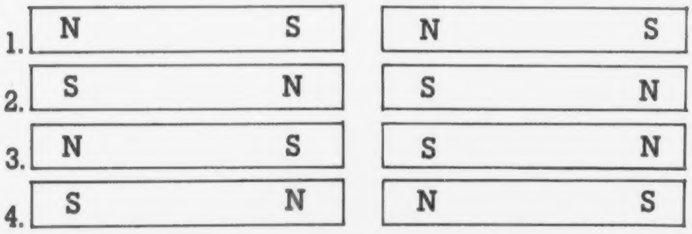
You Will Need:

- Two similar magnets
- Some metal objects

Steps to Take:

1 Take one magnet and hold it close to some metal objects. Describe what happens.

2 Place the two magnets near each other and end-to-end, as shown below:



3 What happens each time? Think about the pushes and pulls, or the attraction and repulsion. Summarise your findings from these observations.

In this section you have distinguished between magnetic and non-magnetic materials and investigated the poles of a magnet.

HEY - THE EARTH'S POLES JUST REVERSED!!
... OR IT COULD HAVE BEEN A GUST OF WIND WHEN THE DOOR WAS OPENED...

In the next section we will look more closely at the strengths of magnetic forces.

MAGNETIC FORCES AND THE MAGNETIC FIELD

Let's find out more about magnetic attraction and repulsion.

EXPERIMENT 5

Are some magnets stronger in attracting (or repelling) objects?

Work in groups of three or four.

You Will Need:

- A variety of magnets

Steps to Take:

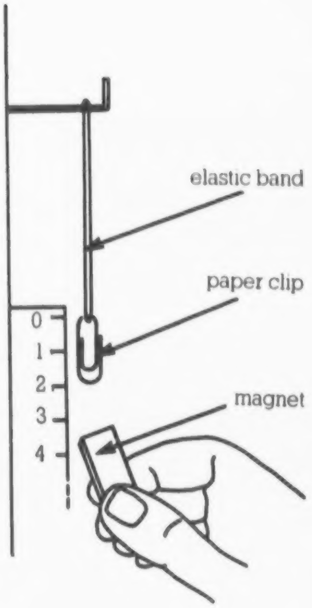
1 Test the magnets.

2 Are some magnets stronger in repelling or attracting other magnets?

3 Now test each magnet with some pins.

EXPERIMENT 6

How can you measure magnetic forces?



You Will Need:

- A force measurer. Construct one as shown in the diagram. Add a scale (some equally spaced marks, e.g. 1 cm apart). Number this scale from zero and make sure the zero is level with the end of the elastic band.
- Three magnets of varying strengths.

Steps to Take:

1 Bring one end of a magnet to the paper clip. *Gently* pull the paper clip down with the magnet. Keep pulling until the paper clip just breaks free, and the elastic band springs back. You are measuring the pulling strength (force) of the magnet.

2 What is the reading of the force at the point where the clip breaks free?

Do this three times with the first magnet and put your results on a table like that below.

3 Does it matter which pole of the magnet you use? (If you are not sure of the answer, do the experiment again using the other end of the magnet. Put your results in a table like that below and compare them.)

4 Repeat these steps with two other magnets. Make sure you get a range of magnets, from weak to strong.

Magnet No. 1			**Magnet No. 2**			**Magnet No. 3**		
Force reading			Force reading			Force reading		
N-Pole	S-Pole	Average	N-Pole	S-Pole	Average	N-Pole	S-Pole	Average

5 Find the average of your results for each magnet.

6 Compare the average magnetic forces you obtained, and put the magnets in order of their strength.

7 Why do you think it is better to use the average force reading for your comparison? Discuss this with your partner.

8 Do you think a magnet's strength is the same in the middle as it is at the poles? Measure it and see if you are right.

EXPERIMENT 7

Can you see a force field?

You Will Need:

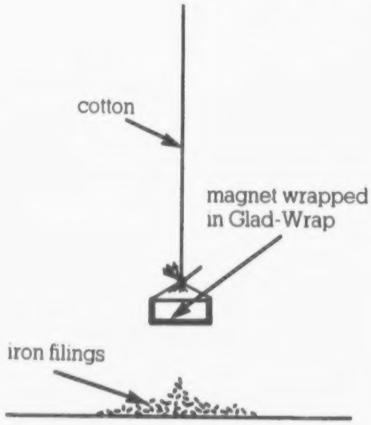
- A bar magnet
- Cotton
- Gladwrap or similar plastic film
- Iron filings

Steps to Take:

1 Take a bar magnet and wrap it in Gladwrap or something similar. Tie a piece of cotton around its middle.

2 Holding the magnet by its cotton, dip it into a pile of iron filings and then lift it out.

3 Describe in your notebook what you see and draw a diagram of it.



A **magnetic force field** is the area around a magnet where its force works.

EXPERIMENT 8

Can you see lines of force in a force field?

You Will Need:

- An acetate sheet
- A bar magnet

- Iron filings
- Wooden blocks (or something similar for support)

Steps to Take:

1 Place a bar magnet on the desk.

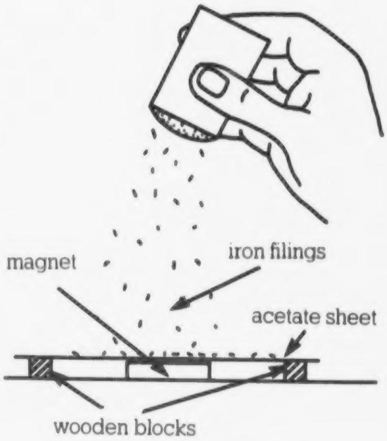
2 Lay a piece of acetate sheet over the magnet and get it flat by supporting the edges with wooden blocks.

3 *Gently* sprinkle a small amount of iron filings on to the sheet, over the magnet. Lightly tap the acetate sheet from time to time to help spread the iron filings. Look at other groups to see how their efforts are turning out.

4 Describe the pattern that appears over the magnet.

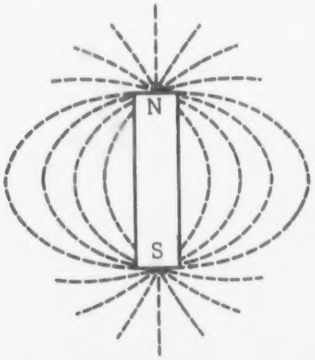
5 Draw a diagram of the patterns formed by the iron filings. Compare it with your diagram of the iron filings sticking to the magnet that you drew earlier.

6 Compare your patterns made by the iron filings in the **magnetic force field** with patterns made by other groups.



7 (a) Why do you think that the lines of magnetic force can be called a 'force field'?

Can you see any differences in the patterns made by the magnets you know to be stronger or weaker than yours? How are they different?



A typical magnetic field around a magnet will look like this.

There are more lines of force around the poles than in the middle of the magnet. This shows that the magnetic force is stronger at the poles than in the middle.

EXPERIMENT 9

How are force fields different?

You Will Need:

- An acetate sheet
- Two bar magnets
- Iron filings
- Wooden blocks (or something similar for support)
- Any other magnets that your teacher has available for investigation

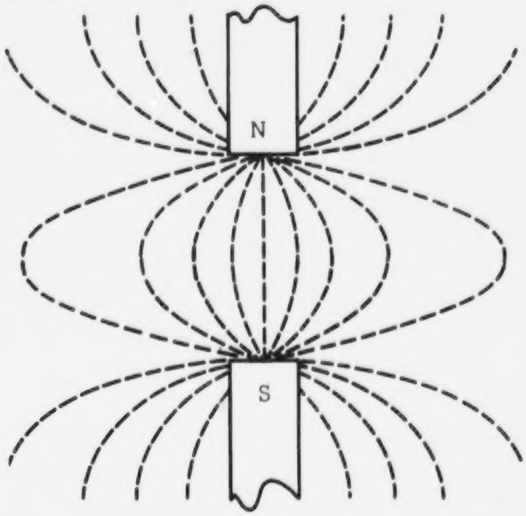
Steps to Take:

1 Investigate what the force field looks like when the north and south poles of two different magnets are facing each other. Leave a small space between the magnets and place a piece of acetate sheet over them. Sprinkle iron filings on the sheet as before.

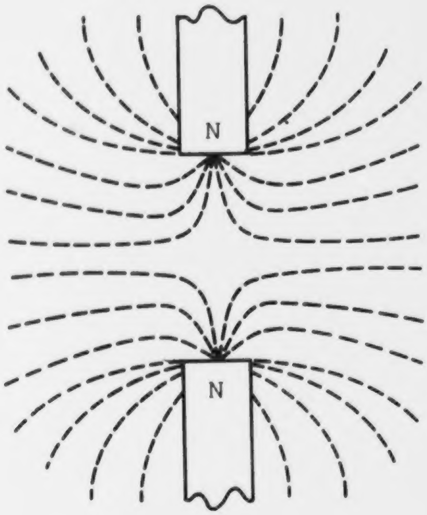
2 What do the lines of magnetic force look like? Draw them in your book and label the diagram.

3 Collect the iron filings again. Reverse one of the magnets so that they are repelling now. Sprinkle iron filings as before.

4 What do the lines of magetic force look like? Draw them in your book.



The force field around two magnets that are **attracting**.



The force field around two magnets that are **repelling**.

Notice the lines in force fields don't cross or touch each other.

EXPERIMENT 10

What happens when you join two magnets together?

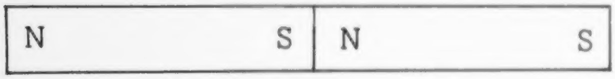
Consider what the magnetic force field will look like if you put two magnets end to end.

You Will Need:

- An acetate sheet
- Two bar magnets
- Iron filings
- Wooden blocks (or something similar for support)

Steps to Take:

1 Draw what you think the magnetic force field will look like if you place two bar magnets like this.



2 Carry out the experiment and see if what happens agrees with your diagram.

3 Do these magnets behave as though they are one single magnet or two separate ones?

4 Compare the force field you get with the previous diagrams you have drawn.

5 Discuss your results in your group.

We have compared and measured magnetic forces and investigated the magnetic fields of magnets.

MAKING MAGNETS

Let's try making some magnets in the laboratory.

EXPERIMENT 11

Can you magnetise something?

You Will Need:

- Two magnetic substances that are not magnets, e.g. two pins, paper clips, razor blades, hacksaws, needles.
- A bar magnet

Steps to Take:

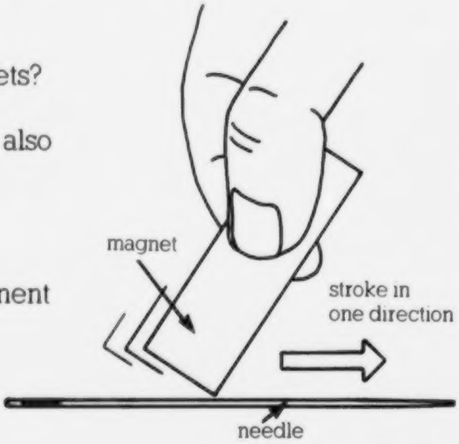
1 Check that the objects you are using aren't behaving as magnets. How can you do that? Note down why you think it is important to do so.

2 Take a magnet and using one pole only, stroke the length of one of the objects several times in the *same direction.* After a few strokes, test to see if the object behaves as a magnet.
   - Does it attract the other magnetic objects?
   - Is it attracted and repelled by other magnets?

3 Do the same to a second object and see if it also behaves as a magnet.

4 Record whether you have made magnets.

5 What do you think makes some magnets permanent and others not?



EXPERIMENT 12

How is a magnet made?

In this activity you can see how a magnet is made in more detail.

You Will Need:

- A test-tube and stopper
- Iron filings
- A compass

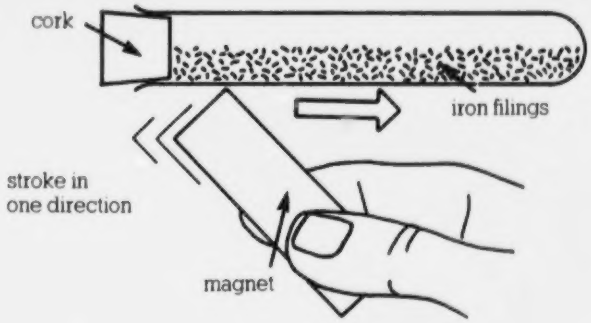
Steps to Take:

1 Half fill a test-tube with iron filings.

2 Seal the mouth of the test-tube and lay it on its side on the desk.

3 Record your observations. Are all the iron filings lying the same way?

4 Stroke the test-tube a few times with a magnet. Make sure you always stroke in the same direction.



5 Look again and record your observations. What has happened to the iron filings?

6 From time to time test the polarity of the ends of the test-tube with a compass. Which end of the test-tube is north?

Compasses are made of magnets suspended so that they can swing easily. The north-seeking pole of the magnet points in the direction of the north pole of the earth.

ACTIVITY 1

What is orienteering?

In this activity you will need to use a compass to follow a trail. Make the trail away from buildings. Why do you think that this is important?

You Will Need:

- A sketch map of the school grounds
- A compass

Steps to Take:

1 Work in pairs and decide upon a trail through the school grounds.

2 Give another pair your map and a compass and let them see if they can follow your trail.

3 When you have all finished, you can discuss in class how each pair found the exercise and what difficulties they may have had using the compass. Think about how explorers used compasses and also navigated by the stars. What problems might they have had?

The Earth behaves like a giant magnet, with north and south poles. Small particles of magnetic material may line themselves up with the north and south poles of the Earth's magnetic field. You have also thought about compasses.

USES OF MAGNETISM

Magnetism has been useful to us for centuries. For example, compasses have been used for mapping and navigation.

Magnetic tape is used in audio and video cassettes to record electronic messages. The following activity will challenge your ability as a scientist.

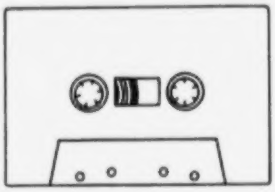
EXPERIMENT 13

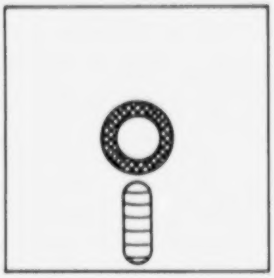
What is the effect of a magnet on computer discs or audio tapes?

Work in groups of three of four for this activity.

You Will Need:

- Some used computer discs or audio tapes
- A bar magnet





Steps to Take:

1 First of all check that the disc or tape works.

2 Work out two or three ways to use your magnet to treat the disc or audio tape. Try to use the same tape or disc for the different treatments. (You may find it more convenient if each group works on one treatment and then pools the results at the end of the class.)

3 Now play the tape or disc and record what has happened to it.

4 Discuss explanations for your results.

5 Write a report on what you have found out.

From what you have found in this activity, you could make a study of how good different brands of audio tapes are.

You could look up some issues of the magazine called *Choice* which would provide you with plenty of information about different brands of disks, video tapes and audio tapes.

ACTIVITY 2

What else do we use magnets for?

For this activity you will need to work as a class. This activity is a combination of looking at demonstration materials and research.

Steps to Take:

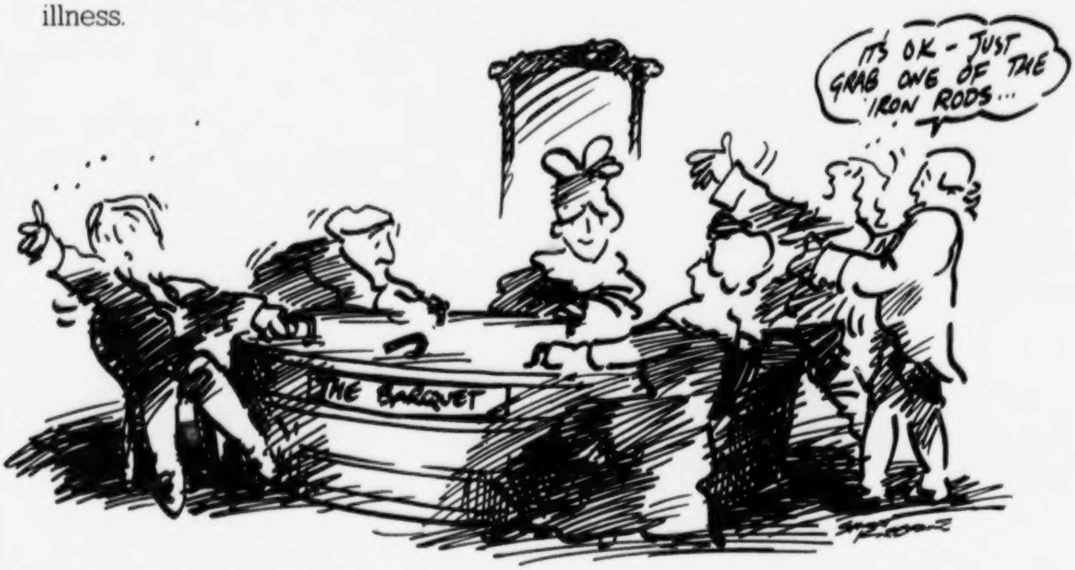
Make up a list of places where magnets are found in everyday life. You may need to do some research in the library, or do some interviews.

ACTIVITY 3

Can magnets be used to cure people?

Steps to Take:

1 Look at the following illustration. It shows how the physician Mesmer used large magnets to try to cure illness.


IT'S OK - JUST GRAB ONE OF THE IRON RODS...
THE BAQUET

Do you think magnetism could be used to cure illness?

2 In fact, Mesmer did cure a number of people. Discuss whether you think the magnets had anything to do with the cures. *Hint! Find out who Mesmer was.*

The records on computer discs, and on audio and video tapes are stored magnetically. We use magnetism in many different ways in our lives.

SUMMARY

- Forces are pushes and pulls. Magnetism is an example of a force.
- Magnetism is a force that can act at a distance.
- Objects that are attracted by a magnet are said to be magnetic.
- Magnetic forces affect materials containing the metals iron, nickel and cobalt. Magnets are made of materials containing one or more of these metals.
- When you bring two magnets towards each other they will be **attracted** (move towards each other) or **repelled** (move apart) depending on which poles you have facing each other.
  Like poles always repel each other
  Unlike poles always attract each other
- Magnets are used in compasses and identify the poles of the earth's magnetic field.
- Magnetic forces can be measured and compared.
- Magnetic lines of force are distributed around and between its poles to form a 'field' or area that the magnet can affect.
- Magnetic forces are strongest where there are more lines of force concentrated together.

  Magnetic forces:

  - weaken with distance
  - are strongest at the poles
  - are weakest to the sides of the magnet.

- **Magnetic lines of force don't cross or touch each other.**
- **Separate bar magnets joined together in a single line act as one single magnet with two poles.**
- **Magnets have a number of applications including their use in electrical machines.**
- **Audio and video tapes and computer discs store information in magnetic form which can be erased by magnetic fields.**

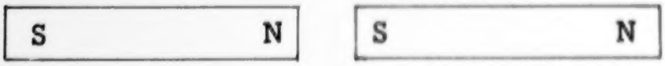
REVISION QUESTIONS

1 Which are the strongest parts of a magnet?

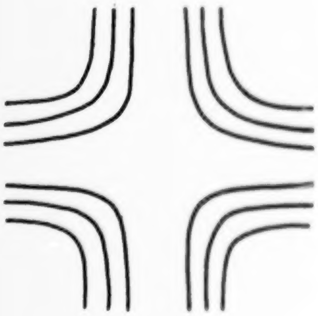
2 How does a compass work?

3 List eight objects in the classroom which you would expect to be magnetic.

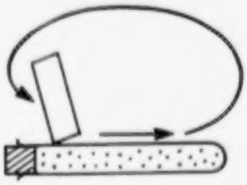
4 Draw the lines of force for the two magnets as shown.



5 How would you account for the following field of force?

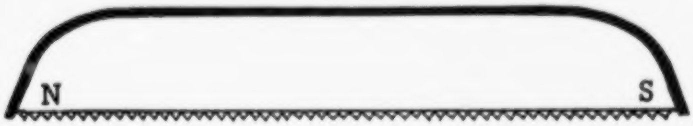


6 Describe what will happen to the iron filings.

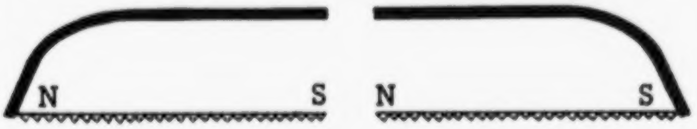


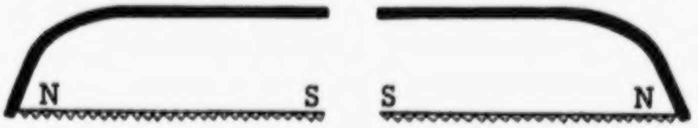
7 A two-cent coin was accidentally dropped into a water drain. A student tried to get it out again by lowering a magnet down into the drain. Would you expect this to work?

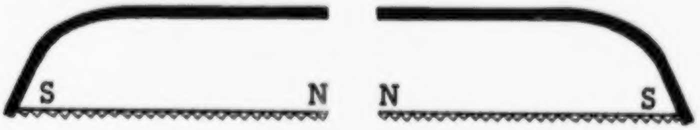
8 A magnetised hacksaw blade has two poles as shown in the diagram.

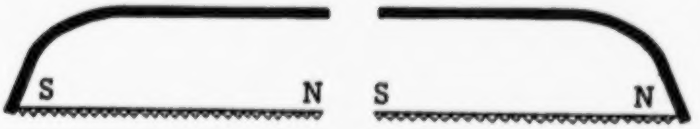


If it were broken into two halves, which of the diagrams below would show the resulting poles.









9 You have two magnets of differing strength. How could you compare the strength of these magnets?

8 HEATING AND SEPARATING CHEMICAL SUBSTANCES

Have you ever considered that the world around us is made up of chemicals? Everything we eat, breathe, touch and see is made up of chemicals. In this chapter we will start investigating chemicals by looking at the effect of heat on some common chemical substances. Finally you will learn how to separate some mixtures of chemicals and get some pure substances.

PHOSPHATE AERATED
BAKING POWDER

Can you give the chemical names of these substances?

When you have completed this chapter you should be able to answer questions like:

- What are the chemical names of some common substances?
- Can you heat substances safely?
- What happens when substances are heated?
- How carefully can you observe changes that occur when substances are heated?

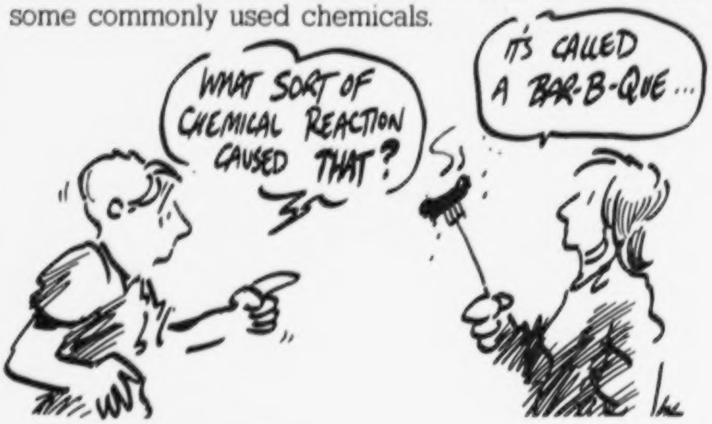
- Can you accurately record your observations?
- How can observations be grouped or classified?
- How can mixtures of substances be separated?

WHAT IS THE EFFECT OF HEAT ON SUBSTANCES?

One way a scientist investigates substances is by **changing** them in some way or another. This can be done by:

1 adding chemicals;
2 passing an electric current through a substance; or
3 heating a substance

In this section we are going to investigate substances by heating them. You will also become familiar with some commonly used chemicals.


WHAT SORT OF CHEMICAL REACTION CAUSED THAT?
IT'S CALLED A BAR-B-QUE...

EXPERIMENT 1

What happens when substances are heated?

In this activity you will find out how various substances are affected by heat. The experiment will be in four parts. You will need to work with a partner.

You Will Need: (for each part of the experiment)

- A Bunsen burner
- A ceramic mat
- A test-tube holder
- A test-tube rack
- A pair of tongs or a test-tube holder
- Nine hard glass test-tubes, 75 mm × 12 mm
- A spatula
- A blue glass

In this experiment you will need to make careful observations. Then you will need to accurately record these observations. To help you, make up a table like the one below.

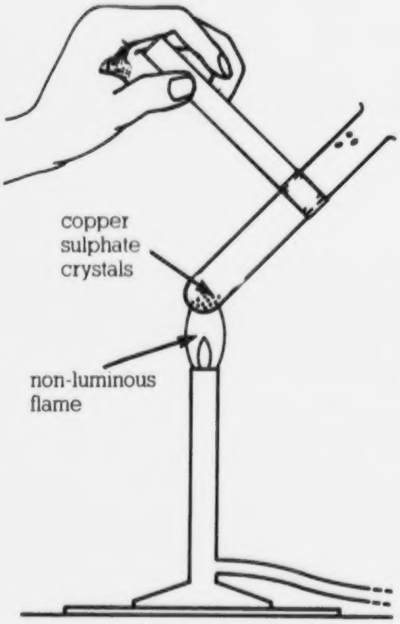
	Observations of chemicals before, during and after heating		
Name of chemical	Appearance before heating	Appearance after heating	Appearance after cooling
1. Copper sulphate	blue crystals		

PART 1 What happens when copper sulphate crystals and cobalt chloride crystals are heated?

You Will Need:

- Copper sulphate crystals
- Cobalt chloride crystals

Steps to Take:



1 Use a spatula to add a small amount of copper sulphate to a test-tube. There should be just enough copper sulphate to cover the bottom of the test-tube.

Make a note of what the crystals look like, for example, what colour are they?

2 (a) Adjust the Bunsen burner flame. It should be non-luminous (not yellow) and about 5 cm high. (You may need to open or close the air hole.)

(b) Use a test-tube holder to hold the test-tube.

(c) Gently heat the test-tube containing the copper sulphate crystals.

Safety! Always keep the mouth of the test-tube pointed away from yourself and other people. Always move the test-tube gently backwards and forwards through the flame.

3 Make a note of any changes you observe in the crystals.

When the crystals are heated water vapour is produced. Look at the cooler parts of the test-tube to see if you can see drops of liquid.

Record your observations in the table.

4 Allow the test-tube to cool in the test-tube rack. Record your observations in the table.

5 Use a second test-tube to heat a small amount of cobalt chloride crystals.

6 Record your results in the table.

PART 2 What happens when zinc oxide and iodine crystals are heated?

Safety! Do not breathe in any iodine fumes.

You Will Need:

- A small crystal of iodine
- Zinc oxide powder

Steps to Take:

1 Take *one* small crystal of iodine in a test-tube and describe what it looks like. Record your observations in the table.

2 Using a small flame gently heat the tube. Describe what you see.

Look at the cooler part of the tube. What do you notice?

3 Allow the tube to cool in a test-tube rack and make a record of what you see.

4 Now take a second test-tube and add a small amount of zinc oxide.

5 Record your observations before and after heating the zinc oxide.

PART 3 What happens to potassium permanganate, copper foil and magnesium ribbon when heated?

You Will Need:

- Potassium permanganate
- A 2 cm^2 piece of copper foil
- About 2 cm of magnesium ribbon
- A piece of blue glass

Potassium permanganate

Steps to Take:

1 Put a small amount of potassium permanganate in a test-tube and record what it looks like.

2 Heat the potassium permanganate over a low Bunsen burner flame. Record what you observe. Can you hear anything?

3 Let the test-tube cool and record what is left at the bottom.

Copper foil

Steps to Take:

4 Describe the copper foil.

5 Using the tongs, heat the copper foil by holding it in the Bunsen burner flame. Record your observations of the foil while it is heating and after it has cooled.

Magnesium ribbon

Your teacher will demonstrate this part of the experiment.

Safety! Do not look directly at the brilliant flame of the burning magnesium. It may damage your eyes.

Steps to Take:

6 Make a record of what the magnesium ribbon looks like.

7 Use a blue glass to observe what happens when magnesium ribbon is heated.

8 What do you observe when the heated magnesium ribbon has cooled?

9 Are the effects of heat on these three substances similar?

10 From all the information you have collected in Parts 1, 2 and 3:
- (i) which of the substances changed permanently when heated? (Permanent change.)
- (ii) which of the substances seem to be the same after cooling as before heating? (Temporary change.)
- (iii) are there any substances which did not change during the whole process? (Unchanged.)

11 Draw up a table like this and list the substances in it.

Effects of heat on chemicals		
Permanent change	**Temporary change**	**Unchanged**

You can see that heating can have different effects according to the chemical being heated. Now you can compare the effects of heat on some other substances with those you have already tested.

PART 4 Comparing the effects of heat on other chemicals

You Will Need:

- 10 cm aluminium foil

- 1 cm lead foil
- Steel wool
- Crushed coal
- Paper
- Dry, clean sand
- Water
- Wood chips
- Red lead
- Sodium chloride (table salt)
- Baking soda
- Test-tubes
- Tongs
- Test-tube holder
- Test-tube rack
- Bunsen burner
- Heat-proof mat

Safety! Remember to take care when heating the chemicals. Never point the mouth of a test-tube at anyone and never get too close to what you are heating.

1 Look at each of the substances in turn and make a record of its appearance.

2 Draw up a table to record your results.

3 Heat each substance using either a test-tube or the tongs as appropriate. Record what happens.

4 Again record what happens when the substance has cooled.

5 Describe how you would group each of these chemicals according to the effect of heat on it. Refer to the second table in Experiment 1.

You have seen how some substances appear to change permanently when they are heated. How did we know that the changes were permanent? We knew because what was produced after heating the original substance was different from the original substance, and it did not change back to the original substance when it cooled.

It has undergone a **chemical change**.

...ANY CHANGE AFTER HEATING?
...TOTAL DESTRUCTION.

Heating substances is one way of investigating them. In this section you have investigated the effects of heat on a number of substances. You have observed that heat causes a permanent change in some substances, a temporary change in others, while some substances remain unchanged by heat.

SEPARATING MIXTURES

When two or more substances are mixed *without* a chemical change happening we call the combination of substances a **mixture**.

For example, when salt is added to sand we say we have a mixture of salt and sand. As no chemical change has taken place it is possible to separate the salt from the sand.

We will investigate ways of doing this.

ACTIVITY 1

Thinking about mixtures

Steps to Take:

1. Write down some of the mixtures that we commonly make, for example, cordial.
2. Why might we need to be able to separate mixtures? Think about how sewage can be treated to make clean water and dirty petrol can be filtered and used again.
3. Discuss your ideas with your group.

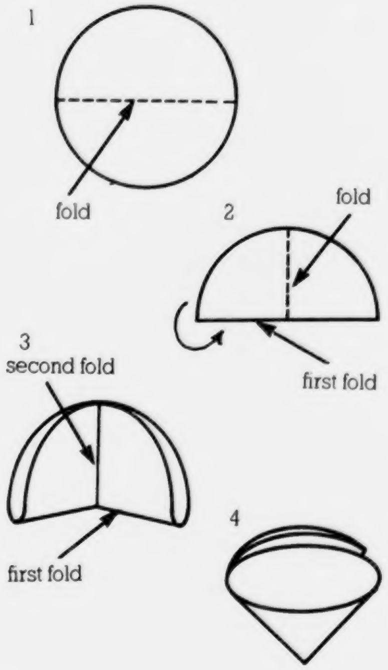
We can use what we have learned in Chapter 5 about substances that are soluble or insoluble in water.

EXPERIMENT 2

How do you separate sand from water?

You Will Need:

- Some clean, dry sand
- A teaspoon
- A beaker (100 mL or smaller)
- Filter paper
- A filter funnel
- A conical flask



Folding a filter paper.

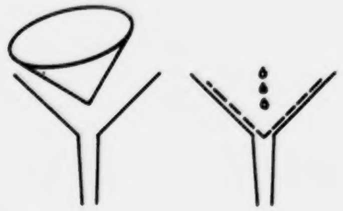
Steps to Take:

1 Add a teaspoon of sand to half a beaker of water. Stir thoroughly and record your observation.

2 Fold the filter paper along the dotted lines as shown in the diagram.

3 Put the filter paper in the funnel. Moisten it with a few drops of water from the tap. This will stop the filter paper popping out of the funnel.

4 Rest the funnel in the top of the flask.

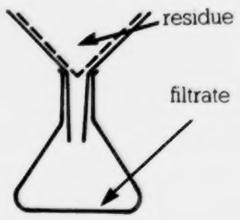


5 Carefully pour the mixture of sand and water into the filter paper. Take care not to let the mixture pour over the top of the filter paper.

6 Record your observations.

7 Can you suggest why water passes through the filter paper and the sand does not.

Put your used filter papers in the bin. Do not throw them down the sink!



The process we used in this experiment is called **filtration**. The liquid that comes out of the funnel is called the **filtrate**. The material found in the filter paper is called the **residue**.

In Experiment 2 the residue was sand.

EXPERIMENT 3

Can you separate copper sulphate from water using filtration?

You Will Need:

- Some copper sulphate
- A beaker (100 mL or smaller)
- Filter paper
- A filter funnel
- A conical flask

Steps to Take:

1 Add a teaspoon of copper sulphate to half a beaker of water. Stir thoroughly and record your observations.

2 Fold a filter paper as you did in Experiment 2 and place it in the filter funnel. Moisten the filter paper.

3 Rest the funnel in the top of the flask.

4 Carefully pour the mixture into the filter paper.

5 Write a report on your findings.
   (a) What was the colour of the original mixture?
   (b) What was left in the filter funnel?
   (c) What was the colour of the filtrate?

EXPERIMENT 4

Can you separate sand from copper sulphate?

Steps to Take:

Work out a way to separate sand from copper sulphate. Describe your experiment and include a labelled diagram in your written report.

EXPERIMENT 5

How can you separate salt from sand?

You will need to work in pairs.

Steps to Take:

Work out a way in which you can separate the salt from the sand using what you have learned so far. Describe what you have done.

ACTIVITY 3

What else can you find out?

1 How would you find out if soil contains substances that are soluble in water?

2 How would you find out if the tap water at home is pure?

3 Find out why the separation process of filtering is important in the mining industry.

So far we have looked at ways of separating substances using filtration. We are now going to look at separating substances by a process called **sedimentation**.

EXPERIMENT 6

What's another way of separating sand from water?

You Will Need:

- A test-tube
- A test-tube rack
- A small beaker
- Sand

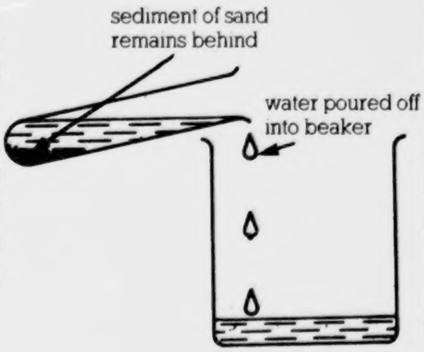
Steps to Take:

1 Add a little sand to a small amount of water in a test-tube.

2 Shake the test-tube gently and place it carefully in the rack.

3 Describe what happens to the sand after a few minutes.

4 Pour off the water from the sand, as shown in the diagram.



When small parts of a substance (grains of sand in Experiment 6) are spread evenly throughout a liquid (water, in our experiment) we say we have a **suspension**.

Sedimentation is the process in which the particles in a suspension are allowed to settle to the bottom of the container. You used the process of sedimentation in Chapter 6, when you allowed soil to settle in a measuring cylinder.

We are now going to look at another way of separating things using a process called **distillation**.

EXPERIMENT 7

Is ink a single substance?

There are two parts to this experiment.

You Will Need:

- A small beaker
- Sand
- Two test-tubes
- An angled connection tube with cork
- Ink (Quink)
- Filter paper
- A filter funnel
- A conical flask
- A one-hold stopper
- Two test-tube holders

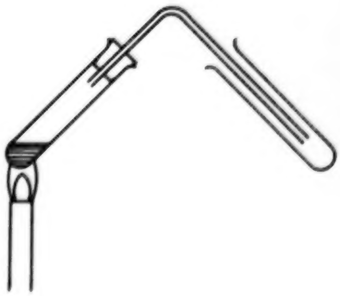
Steps to Take:

PART 1 Filtration

1 Filter a small amount of ink using the same steps outlined in Experiment 2.

2 Describe the residue and the filtrate.

PART 2 Distillation



1 Assemble the apparatus as shown in the diagram. Use about 3 mL of ink.

2 Adjust the Bunsen burner flame for gentle heating.

3 While holding both test-tubes, gently heat the test-tube containing the ink until the ink boils. Try not to let the ink froth.

4 Observe what happens in the second test-tube.

5 Stop heating the ink before it becomes dry. What happens in the second test-tube when the heating is stopped?

6 (a) Is ink a single substance or a mixture?
  (b) Can you explain what has happened?
  (c) Remember Experiment 4 on page 202? How could you use what you found out in that experiment to separate these substances?

The process of separation we used in this experiment was **distillation**. Distillation involves heating a liquid until it becomes a vapour, condensing the vapour by cooling it and collecting the condensed vapour. In this way a liquid can be separated from a solid.

We use different methods to try to separate mixtures. We are now going to look at another method, **chromatography**.

In the next experiment we are using **paper chromatography**. It is a method of separating a mixture of solutes dissolved in a solvent by using paper.

EXPERIMENT 8

What else can you find out about ink?

Work in groups of three or four.

You Will Need:

- Two 100 mL beakers
- Two 250 mL beakers
- Filter paper 9 cm diameter (or white blotting paper cut into 9 cm squares)

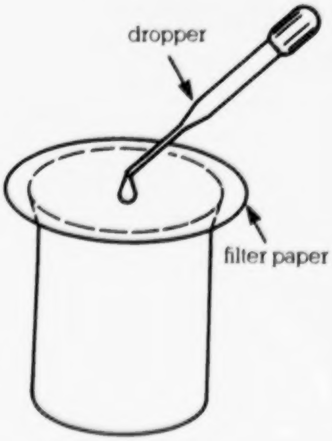
- Strips of filter paper or blotting paper about 10 cm long
- Two droppers
- A test-tube rack
- Four test-tubes
- Methylated spirit
- A selection of inks, biros and felt pens

Steps to Take:

PART 1

1 Place the filter paper on top of a beaker.

2 Use a dropper to transfer a drop of ink to the centre of the filter paper.



3 Add water drop by drop to the centre of the blot. Allow each drop to spread before adding the next.

4 Describe what you see.

PART 2

6 Now repeat the steps in Part 1 using methylated spirit instead of water.

7 (a) What do you observe?

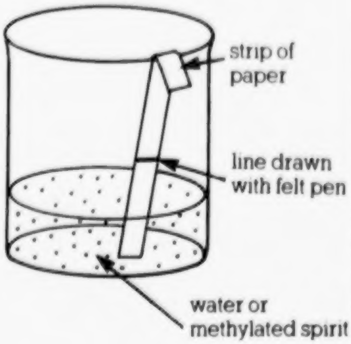
(b) Are there any differences between using water as a solvent and using methylated spirit as a solvent?

8 Explain in your own words what you think happened?

PART 3

In this part of the experiment you can investigate your own biros and felt pens.

9 Draw a line across a strip of filter paper or blotting paper about 4 cm from one end.



10 Place about 2 cm of solvent in a beaker.

11 Place the strip in the beaker as shown in the diagram.

12 Watch to see what happens. Record your observations.

We can use chromatography to investigate the green colouring in leaves. This colouring is called **chlorophyll**.

You can find out if the green chlorophyll is one substance or a mixture of substances.

EXPERIMENT 9

What can you learn about chlorophyll in leaves?

Work in pairs. This experiment is divided into two parts.

You Will Need:

- A test-tube, 100 mm × 16 mm
- A pestle and mortar
- A beaker as support for filter paper
- Filter paper (Whatman No. 1)
- A dropper
- Scissors
- Grass, spinach or silverbeat
- Acetone
- Toluene

Steps to Take:

The first task is to get the chlorophyll out of some leaves.

PART 1 How can you remove the chlorophyll from leaves?

Check first of all whether the green colouring can be separated in the same way that you separated salt from sand.

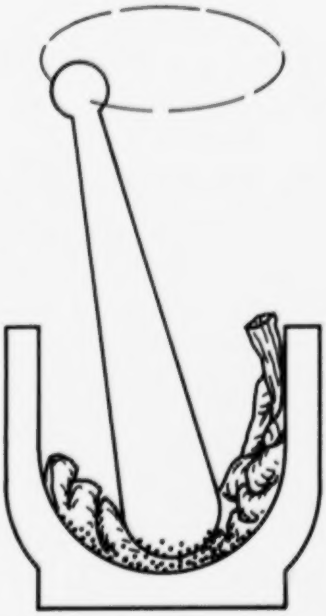
1 Take a small handful of grass or leaves. Cut the grass or leaves into small pieces using scissors.

2 Put the pieces in a mortar. Add about 4 mL of water and grind the mixture with a pestle. Filter the green mixture.

3 Now repeat the procedure using acetone instead of water.

Safety! Make sure that there are no naked flames in the laboratory. Acetone is flammable!

4 Which of the solvents brings out out the chlorophyll?



PART 2 Is the green colour one substance or a mixture of substances?

1 Rest a filter paper on top of a beaker.

2 Put one drop of the green liquid from Part 1 on the centre of the filter paper.

3 After the first drop has dried, add another one. Add four or five drops in this way, so that the green is fairly concentrated.

4 Now add separated drops of acetone.

5 Repeat the experiment but use toluene instead of acetone.

Safety! Toluene is inflammable!

6 (a) What happens in each case?

(b) Is chlorophyll a mixture?

You have looked at a number of ways in which the substances in a mixture can be separated. In particular you have looked at filtration, sedimentation, distillation and chromatography as ways of separating mixtures.

FURTHER ACTIVITY

Describe other ways which may be used to separate substances.

SUMMARY

- **One way of investigating substances is to heat them.**
- **Some substances when heated undergo a permanent change, others a temporary change, and others remain unchanged.**

- **Mixtures of substances may be separated by the following processes:**
  - **filtration**
  - **sedimentation**
  - **distillation**
  - **chromatography.**
- **Ink and chlorophyll are mixtures of various substances.**

REVISION QUESTIONS

1 What are some ways that you could check whether cocoa is a single substance or a mixture?

2 Substance X is found as crystals. When heated it changes colour and a gas is given off. When a few drops of water are added to the heated substance it returns to its original colour.

(a) What would you predict the gas given off is?

(b) How could you test whether your idea is correct?

3 Iron filings are insoluble in water while sodium chloride is soluble. List the steps you would take to recover the pure iron filings and sodium chloride from a mixture of the two substances.

APPENDIX 1 WRITING REPORTS

A scientist should let other people know:

- how an experiment was carried out
- what was discovered

by writing a **practical report.** A practical report always has certain parts:

- It has an **aim** – telling us what the scientist is trying to find out (the idea or hypothesis being tested).
- Then the scientist records the equipment and materials required.
- The next thing is to write the description of how the experiment was done. Whenever possible, a diagram is drawn of the equipment set up. This is part is called the **method.**
- Scientists then write down all the things they can see happening (their observations) or record any measurements taken. This is called **recording the results**. They put the results in a special results section.
- After doing all this, they then check to see whether or not the results support the hypothesis made at the beginning. At this stage they usually discuss what they have found with other scientists. In this way they can share ideas.
- The end result is given in a **conclusion**. The conclusion is statement of what is learned from the experiment.

GLOSSARY

anther top part of the stamen: sac-like structure containing pollen
average calculated by adding the readings and dividing by the number of readings
biologists people who study animals and plants
binocular vision having two eyes at the front of the head, so that what is seen has depth
cells the basic building blocks of living plants and animals
chlorophyll the green pigment in plants that allows them to absorb the sun's energy
cochlea part of the ear concerned with the reception of sound
colour blindness an inherited problem with eyes: people with this problem often cannot distinguish between certain colours
conclusion statement of what is learned from an experiment
condensation process of a vapour or gas being converted to a liquid e.g. the formation of water droplets when steam meets a cold surface
controlling variables the way in which you change one variable while keeping the rest the same
convex lens a lens which is thicker at the centre than at the edges. (It makes rays of light come together at a point.)
compost a mixture of decayed plant matter added to the soil to increase its humus and mineral salt content
cornea layer of tissue at the front of the eyes: light can readily pass through it (transparent).
cotyledon a seed leaf
cytoplasm jelly-like substance surrounding the nucleus in a cell
decibel unit measuring the loudness of sound
energy something that makes things work, move, or change. Energy exists in many forms such as heat energy, light energy, nuclear energy and mechanical energy.
evaporation the process whereby a liquid turns into a vapour.
eustachian tube a tube leading from the middle ear to the back of the throat. It contains air. (Its function is to ensure that the air pressure inside the middle ear is equal to that of the atmosphere).
excretion the removal of waste products from the body. These are the end products of nutrition and respiration. They include carbon dioxide, water and urea.
fertilization the union of a male and female reproductive cell.

fibrous root one of *many* roots that grow from the base of a stem. There is no tap root.

filtrate the solution which has been passed through a filter.

force a push or a pull. Some common examples are gravity, flowing water, wind and magnetism.

gravity the force of attraction exerted by the Earth and all that surrounds it.

humus a dark brown material found in the topsoil produced by decay of plant and animal tissues. Humus contains many nutrients and helps to retain water. Hence it is important for plant growth.

hypothesis a general statement made in an attempt to explain a set of observations. The statement is made as a basis of an investigation. For example, seeds require moisture to germinate.

iodine solution a stain that goes a blue-black colour when added to starch

iris the circular coloured ring of muscular tissue in the front of the eye. It has a circular opening, the pupil, through which light enters the eye. The iris controls the size of the pupil and hence the amount of light reaching the retina.

loam a mixed soil consisting of fine clay, silt, sand and humus. It is very fertile and is the best soil for growing plants.

magnification increasing the size of what we see using lenses: as in a microscope

magnet a solid object which possesses the property of magnetism: it attracts iron, and attracts or repels other magnets. It will lie in a north-south direction when it is free to turn.

magnetic field the area where the force of a magnet acts

magnetic pole the end of a magnet at which magnetism appears to be concentrated.

meniscus the curved upper surface of a liquid in a tube.

nitrogen cycle a cycle of events in which plants absorb nitrogen in the form of salts (nitrates) from the soil. The plants use the nitrogen to build up the proteins in cells. Animals eat the plants. The nitrogen in the animals and plants is returned to the soil when they decay.

optic nerve the bundle of nerve fibres that takes the nerve messages from the retina to the brain.

ossicle one of the three small bones found in our middle ear. They transmit the vibrations of the ear-drum to the oval window.

oval window a thin membrane between the middle ear and the inner ear. It transfers vibrations from the ossicles of the middle ear to the cochlea.

ovule the part of the ovary of a flower that contains a female cell (gamete) and will, after fertilization, become a seed.

oxygen a gas, part of the air we breathe: used in respiration by animals and plants. Produced by plants in sunlight.

petal inner parts of flowers, often brightly coloured.

plumule the seed shoot.

pupil the centre opening in the iris (see iris).

receptor the end part of a nerve that detects light, taste, smell, sound, heat, pain or touch.

reflex action an immediate response caused by a simple stimulus, e.g. the knee jerk reflex.

radicle the seed root.

retina a layer composed of light sensitive cells at the back of the eye. Sends images to the brain by the optic nerve.

reproduction the process by which living things produce new beings: 'sexual reproduction' involves the fertilization of a female cell by a male cell; 'asexual reproduction' can be by budding but does not involve sex cells.

residue the solid material held back when a mixture of a solid and a liquid passes through a filter.

respiration the release of energy from food substances. The process usually requires oxygen. It occurs in the cells of animals and plants.

saturated solution a solution in which no more substance will dissolve.

scale a number series of marks increasing from a low to a high value

semicircular canals three fluid-filled curved tubes situated at right angles to each other. They sense movements in space and help to maintain balance.

sepal an outer part of the flower consisting of a green leaf-life structure.

solubility the amount of substance that can be dissolved in a liquid.

solute any substance that will dissolve when added to water or any other liquid.

solution a liquid containing a solute dissolved in a solvent.

solvent the liquid in which a solute dissolves.

stamens the male reproductive part of a flower: produce pollen from their anthers.

stigma top of the female part of the flower which receives pollen.

suspension tiny insoluble particles evenly spread through a liquid (or gas). If allowed to stand the particles will slowly settle on the bottom of the container and form a sediment.

tap root the main root of a plant. It grows straight downwards and usually has other roots branching out from it. Some tap roots store food e.g. carrots.

taste buds receptors found in groups on the tongue; they are sensitive to taste. Each taste bud is sensitive to only one of four tastes: sweet, sour, bitter and salty.

thermometer an instrument for measuring temperature.

top soil the top layer of soil containing the nutrients required by plants for healthy growth.

variable a condition that can change the result of an investigation.

volume the amount of space an object takes up.

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